Oracle® TimesTen In-Memory Database

Kubernetes Operator User's Guide

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Oracle TimesTen In-Memory Database Kubernetes Operator User's Guide, Release 26.1

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C Create Your Own Oracle Wallet, Certificates, and Secrets for Exposing TimesTen Metrics

About This Content

This document covers TimesTen support for the TimesTen Kubernetes Operator.

Audience

This document is intended for anyone who wants to use the TimesTen Kubernetes Operator in a Kubernetes environment.

Kubernetes is a portable, extensible, open-source platform for managing containerized workloads and services, that facilitates both declarative configuration and automation. The Oracle TimesTen Kubernetes Operator (TimesTen Operator) is a Kubernetes Operator that provides the ability deploy TimesTen databases in a Kubernetes environment.

Conventions

The following text conventions are used in this document.

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
`monospace`	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

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Overview of the Oracle TimesTen Kubernetes Operator

This chapter provides an overview of containers and Kubernetes. It also gives an overview of the TimesTen Kubernetes Operator. It discusses the TimesTenClassic *Custom Resource Definition* (CRD) and the TimesTen Operator. The chapter details the role the TimesTen Operator plays in deploying, managing, and monitoring active standby pairs of TimesTen Classic databases in your Kubernetes cluster.

Topics:

Overview of Containers and Kubernetes

A container is a lightweight virtual machine, running the Linux operating system. A container usually runs one application that is started from an image. Files that are created and modified are usually not persistent. However, persistent storage is available. Containers are a key component of cloud computing environments.

Kubernetes is a portable, extensible, open-source platform for managing containerized workloads and services, that facilitates both declarative configuration and automation. Kubernetes has the ability to manage the resources of multiple hosts (called *Nodes*) in a cluster, and to run containers as required across these nodes. It can automatically spawn containers to react to various failures. Kubernetes also manages the networking among the containers and to the outside world. Kubernetes is portable across many cloud and on-premises environments.

Key Kubernetes concepts include:

- *Pod*: One or more containers that share an IP address. For more information on Pods, see:

  `https://kubernetes.io/docs/concepts/workloads/pods/pod/`
- *Deployment*: A named collection of *n* identical Pods (where *n* is the number of Pods). Kubernetes ensures that *n* identical Pods are running. For more information on Deployments, see:

  `https://kubernetes.io/docs/concepts/workloads/controllers/deployment/`
- *PersistentVolume*: Storage that can be mounted to a Pod and is persistent beyond the lifetime of Pod. For more information on Persistent Volumes, see:

  `https://kubernetes.io/docs/concepts/storage/persistent-volumes/`
- *StatefulSet*: Similar to a Deployment, but each Pod has an associated PersistentVolume. For more information on StatefulSets, see:

https://kubernetes.io/docs/concepts/workloads/controllers/statefulset/

- *Service*: A network endpoint for a Deployment or StatefulSet. It defines the set of addresses and ports that should be exposed to applications in the Kubernetes cluster. For more information on a Service, see:

  https://kubernetes.io/docs/concepts/services-networking/service/

Kubernetes provides the facilities for the provisioning of Pods and other Kubernetes resources that are required to deploy applications. Once deployed, the objects must be monitored and managed.

Kubernetes does some monitoring and managing of applications, but not all. It does handle problems at the Pod level automatically. For example, if a container fails, Kubernetes restarts it automatically. If an entire Node fails, Kubernetes starts replacement Pods on the other Nodes. However, Kubernetes has no knowledge about problems inside a container. This is not problematic for stateless applications, but for databases (which are stateful), Kubernetes needs help managing what is inside the containers.

This help comes in the form of:

- Custom Resource Definition
- Kubernetes Operator

Custom Resource Definition

A *Custom Resource Definition* (commonly known as a CRD) extends the Kubernetes' object model. It adds a new object type to the Kubernetes cluster, similar to the Pod, the StatefulSet, and the Service object types that it natively supports.

Kubernetes Operator

A *Kubernetes Operator* (also called *Operator*) is the brains behind a CRD. An Operator is an application that performs the functions of a human computer operator. It starts, stops, monitors, and manages other applications.

An Operator runs in one or more Pods, one active and the others idle. The active Operator performs the work. The remaining Operators are idle and remain idle until the active Operator fails. The active Operator manages all objects of a particular type and when combined with a CRD enables you to add custom facilities to Kubernetes.

About the TimesTen Kubernetes Operator

The TimesTen Kubernetes Operator configures and deploys both replicated and non-replicated TimesTen databases.

The TimesTen Kubernetes Operator consists of these interrelated components:

- Custom Resource Definitions (CRD): The TimesTenClassic CRD defines an object of type TimesTenClassic to Kubernetes. This TimesTenClassic object type provides the metadata for deploying replicated and non-replicated databases.
- TimesTen Operator: There is one TimesTen Operator. You can deploy it in your namespace at namespace-scope or in a specific namespace at cluster-scope. The Operator monitors TimesTenClassic objects. It deploys, manages, and monitors active standby pairs of TimesTen databases as well as non-replicated TimesTen databases.
- TimesTen Agent: There is one TimesTen agent. This agent runs inside each container that runs TimesTen. The TimesTen Operator communicates with these agents both to

determine the state of TimesTen insides of the container as well as to create, start, stop, and control TimesTen instances. The agent does not know how to manage TimesTen. It gives information to the Operator and the Operator provides the instructions for the agent.

About TimesTenClassic Objects

The TimesTen Operator distribution provides the file you need to deploy the TimesTenClassic CRD in the Kubernetes cluster. Once deployed, Kubernetes understands the TimesTenClassic object type, just as it understands Pods, Secrets, and Services.

You can define objects of type TimesTenClassic. This lets you define the specific attributes for your TimesTen configuration and TimesTen database.

Objects in Kubernetes are named and typed. You can define a TimesTenClassic object named `sample` and another TimesTenClassic object named `sample2`. You can have as many of these Kubernetes objects as you want, limited only by the available resources in your Kubernetes cluster.

Objects of different types have different meanings. For example, an object of type TimesTenClassic has a different meaning than an object of type ConfigMap. Therefore, you can define a `sample` TimesTenClassic object and a `sample` ConfigMap.

Kubernetes supports *namespaces*. Namespaces split a cluster into multiple independent ones. Each namespace has a completely independent set of names. There can be an object of type `a` called `x` in `namespace1` and a different object of type `a` called `x` in `namespace2`. For example, you can define an object of type TimesTenClassic called `sample` in the `namespace1` namespace, and a different object of type TimesTenClassic called `sample` in the `namespace2` namespace.

Note

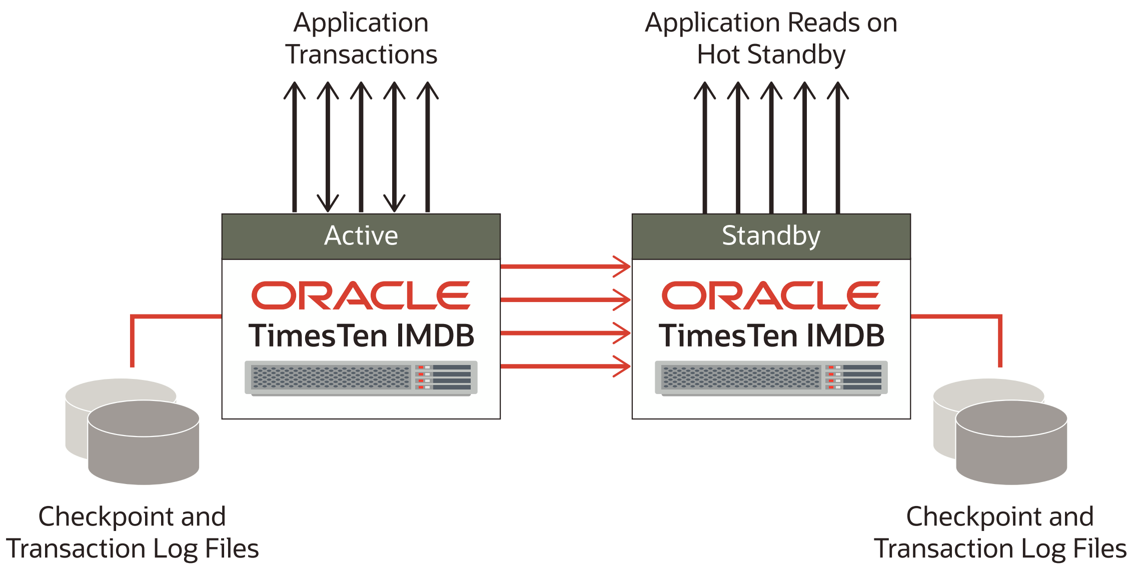
CRDs are cluster-scoped, not namespace-scoped.

Kubernetes object definitions are expressed in JSON or YAML. The examples in this book use YAML.

About Provisioning Active Standby Pairs

TimesTen Classic databases almost always run in active standby pairs. Figure 1-1 illustrates an active standby pair replication scheme. There are two databases. One database is the active, and the second database is the standby. Applications update the active database. The standby database is read-only and receives replicated updates from the active database. Only one of the two databases function as the active database at any one time. If the active database fails, the standby database is promoted to be the active. After the failed (active) database is recovered, it becomes the standby database. See Types of Replication Schemes in the *Oracle TimesTen In-Memory Database Replication Guide* for more information on the active standby pair replication scheme.

Figure 1-1   Active standby pair of TimesTen databases


Application Transactions
Application Reads on Hot Standby
Active
ORACLE TimesTen IMDB
Standby
ORACLE TimesTen IMDB
Checkpoint and Transaction Log Files
Checkpoint and Transaction Log Files

An active standby pair replication scheme is a good fit for Kubernetes. Specifically, consider a pair of Pods, each with persistent storage, that are running an active standby pair of TimesTen databases. If the Pod containing the active database fails, Kubernetes automatically spawns another Pod to take its place, and attaches the appropriate storage to it.

But, since Kubernetes doesn't know anything about TimesTen, it will not automatically perform the necessary operations to cause the standby database on the surviving Pod to become the active database. This is where the TimesTen Operator comes in.

TimesTen provides a CRD that adds the *TimesTenClassic* object type to Kubernetes as well as an Operator for managing TimesTen databases. The Operator automates setup and initial configuration, manages databases and replication, and automates failover and recovery.

When you define a TimesTenClassic object, you can specify the configuration of your TimesTen deployment using Kubernetes facilities. When you create a TimesTenClassic object in a Kubernetes cluster, a pair of Pods are created, each running TimesTen. Each Pod contains a TimesTen instance. Each instance provides one TimesTen database. Database replication, through active standby pairs, is automatically configured. In short, you can deploy highly available replicated pairs of TimesTen databases and manage them by issuing a small number of commands.

A Kubernetes Operator manages objects of a particular type. TimesTen provides an Operator that manages Kubernetes objects of type TimesTenClassic. In so doing, TimesTen can be deployed, monitored, managed, and controlled in an automated manner with no required human intervention.

About Deploying a Replicated TimesTenClassic Object

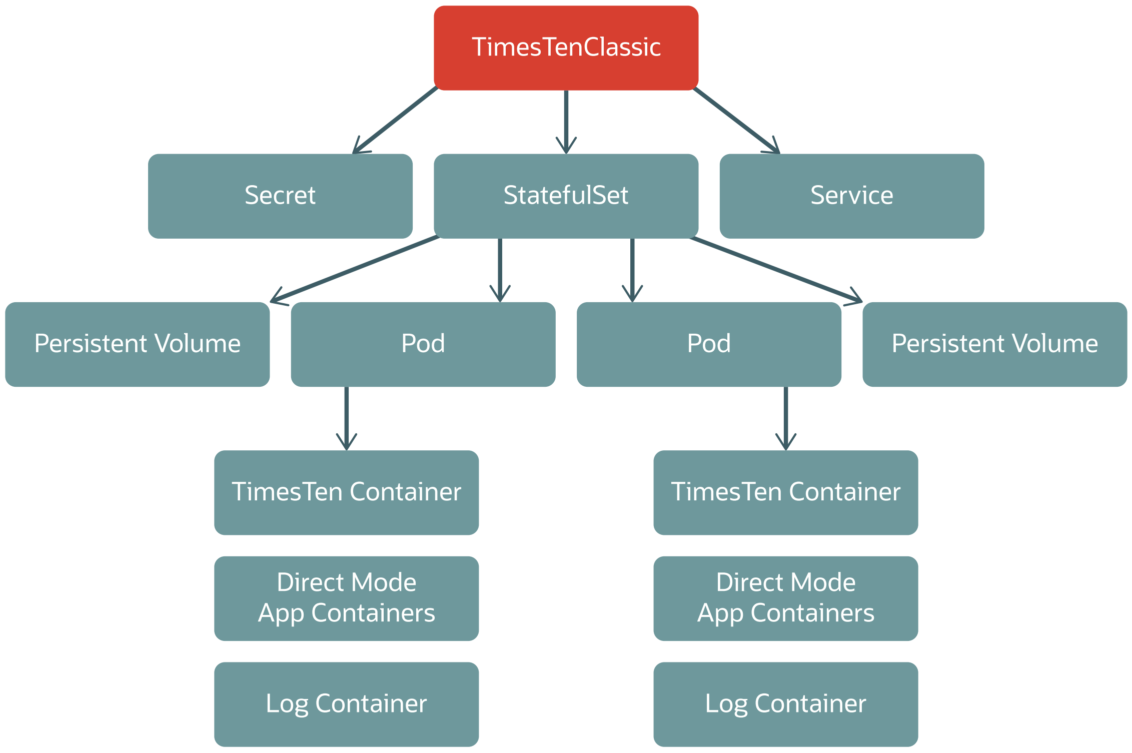
When you create a replicated TimesTenClassic object in the Kubernetes cluster, the process to create and configure your active standby pair of databases begins. The Operator is invoked and creates several Kubernetes objects that are required to run TimesTen. After the objects are created and linked together, the TimesTen containers run a script to configure and start the TimesTen agent. The Operator communicates with the TimesTen agent that is running in each Pod in order to monitor and control TimesTen. The Operator configures one database as the active database, copies the active database to the standby, and then configures the active standby pair replication scheme. The process is described in detail in these sections:

- About Objects Created by the TimesTen Operator
- About the TimesTen Containers and the TimesTen Agent
- Simple Deployment

About Objects Created by the TimesTen Operator

The Operator creates a number of Kubernetes objects that are required to run TimesTen, including a StatefulSet, a Service, and a Secret. These objects in turn create other objects. All of these objects are linked together by Kubernetes and are associated with the TimesTenClassic object you created. Figure 1-2 shows the objects that are created and how they are linked together.

Figure 1-2 Creating the TimesTenClassic object



The objects that are created are described in the following sections:

- StatefulSet
- Service
- Secret
- Pods
- Events

StatefulSet

The Operator creates a StatefulSet consisting of two Pods to run TimesTen. Each Pod has one or more PersistentVolumes (persistent storage), that are mounted in the TimesTen containers. This is where your TimesTen databases are stored. Applications running in the containers with PersistentVolumes mounted can create files that live beyond the lifetime of the container. (By default, all files that containers create and modify automatically vanish when the container exits. Containers are ephemeral.)

One attribute of a StatefulSet is the number of `replicas` that can be provisioned. Each TimesTenClassic object has an associated StatefulSet with two `replicas`. If one Pod fails, Kubernetes automatically creates a new one to replace it, and automatically mounts the appropriate PersistentVolume(s) to it.

For example, for a TimesTenClassic object called `sample`, the Operator creates a StatefulSet called `sample` in the same Kubernetes namespace. The StatefulSet, in turn, creates two Pods in the namespace, called `sample-0` and `sample-1`.

Service

A Kubernetes Service defines the set of network addresses and ports that should be exposed to applications in the cluster.

The Operator automatically creates a *headless* Service when you create the TimesTenClassic object. It automatically associates this Service with the StatefulSet. This causes Kubernetes to define entries in the Kubernetes cluster's DNS for the Pods in the StatefulSet, and to keep those DNS entries up to date.

A headless Service is used such that the DNS name/address entry for the active database is different than the DNS name/address entry for the standby database. This enables incoming client connections to be routed to the database that is active. For more information on a headless Service, see:

https://kubernetes.io/docs/concepts/services-networking/service/#headless-services/

For a TimesTenClassic object called `sample`, a headless Service called `sample` is also created in the same Kubernetes namespace. This results in entries in the cluster's DNS for `sample-0.sample.`*`namespace`*`.svc.cluster.local` and `sample-1.sample.`*`namespace`*`.svc.cluster.local`.

Secret

The TimesTen Operator creates a Secret to inject an SSL certificate into the TimesTen containers. This secures the communication between the TimesTen Operator and the TimesTen Agent.

Pods

The StatefulSet creates two pods. Each Pod contains three containers:

- The `tt` container. This TimesTen container is always present in the Pods. It executes the TimesTen agent and runs TimesTen.
- The `daemonlog` container: This container copies the contents of the TimesTen `ttmesg.log` file to `stdout`, resulting in Kubernetes logging the file. This enables the daemon log of the TimesTen instances to be recorded by the Kubernetes infrastructure.

- The `exporter` container: This container runs the TimesTen exporter. The TimesTen exporter is a utility that exports TimesTen metrics to Prometheus or some other scraping mechanism.

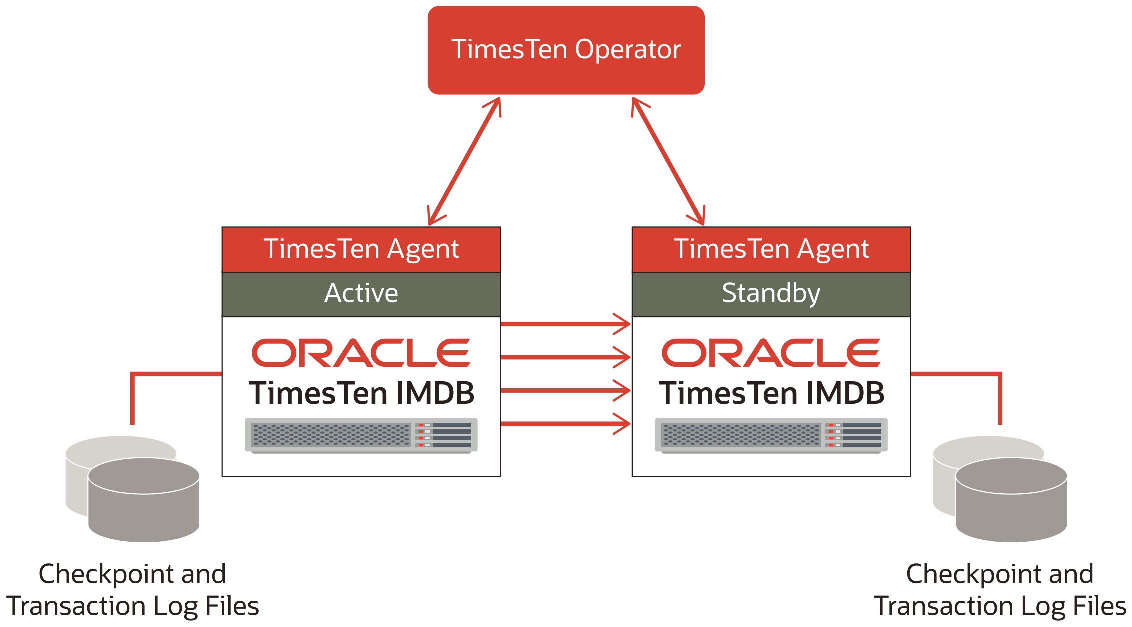
Events

The Operator creates a Kubernetes event whenever important changes occur.

About the TimesTen Containers and the TimesTen Agent

After the objects are created, the TimesTen containers run a script that configures and starts the TimesTen agent. The Operator communicates with the TimesTen agent running in each Pod, in order to configure, manage, and monitor TimesTen in that Pod. The agent provides an HTTPS endpoint in the Pod that the Operator uses to query and control the `tt` container in the Pod. If the TimesTen agent fails, the `tt` container automatically terminates and is re-spawned by Kubernetes. Figure 1-3 illustrates the two way communication between the Operator and the TimesTen agent.

Figure 1-3 The Operator and the TimesTen agent



The TimesTen agent starts TimesTen and thus runs as the instance administrator user. It has full control over TimesTen.

Simple Deployment

The TimesTen Operator is designed for simple deployment of your active standby pairs of TimesTen Classic databases and for automated failure detection and recovery. For example,

- You decide you want to deploy a new replicated pair of TimesTen databases.
- You decide the attributes of those databases.
- You create the configuration files for those attributes.

- You use the `kubectl create` command to create a TimesTenClassic object to represent the replicated pair.
- You use the `kubectl get` and `kubectl describe` commands to observe the provisioning of the active standby pair.
- Applications that run in other Pods use TimesTen's standard client/server drivers to access TimesTen databases.

You do not have to monitor the TimesTen databases continually, configure replication, perform failover, or re-duplicate a database after failure. The TimesTen Operator performs all these functions and works to keep the databases up and running with minimal effort on your part.

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Prepare to Use the TimesTen Kubernetes Operator

Before you can use the TimesTen Kubernetes Operator (TimesTen Operator), you must choose a container image that contains TimesTen and a container registry that contains TimesTen container images. You must also obtain TimesTen YAML manifest files and Helm charts. These files and charts are necessary to deploy the TimesTen Operator.

This chapter discusses your options and then shows you how to perform the tasks for each option.

Topics:

About TimesTen Container Images and Container Registry Options

A TimesTen container image contains everything that is needed to run the TimesTen Operator and TimesTen containers in the TimesTen Pods created by this Operator. You can acquire these container images from a number of container registries. In addition, TimesTen provides a Dockerfile that lets you build your own TimesTen container image that you can then store in a container registry of your choice.

A TimesTen container image stored in a container registry is necessary to run TimesTen and the TimesTen Operator in your Kubernetes cluster.

TimesTen provides several options for obtaining a TimesTen container image for use in your Kubernetes environment:

- Container images on Oracle Container Registry (`container-registry.oracle.com`): TimesTen publishes official TimesTen container images to TimesTen repositories on Oracle Container Registry. The `timesten` repository contains TimesTen container images for Oracle TimesTen In-Memory Database (TimesTen). This repository contains container images that run a licensed copy of TimesTen. Using container images in this repository require that you accept the Oracle license agreement.

  For information about TimesTen, see Overview for the Oracle TimesTen In-Memory Database in *Oracle TimesTen In-Memory Database Introduction*.

  A TimesTen container image on Oracle Container Registry corresponds to a specific TimesTen release. For example, the `container-registry.oracle.com/timesten/timesten/26.1.1.1.0` container image contains TimesTen release `26.1.1.1.0`. Simply scroll through the list of container images on Oracle Container Registry to identify a container image that you want to use when deploying the TimesTen Operator and TimesTen databases in your Kubernetes environment.

- Container images on Oracle Cloud Marketplace: TimesTen provides a container listing called Oracle TimesTen In-Memory Database for Kubernetes - BYOL. You use this listing to export a TimesTen container image into a repository in Oracle Cloud Infrastructure Registry (Container Registry). See Introduction in the *Oracle TimesTen In-Memory Database Using Oracle Cloud Marketplace to Obtain a TimesTen Container Image (BYOL)* guide.
- Build your own TimesTen container image: If you have a TimesTen distribution, you can use the Dockerfile file provided in this distribution to build a TimesTen container image. You can then tag and push this container image to a container registry of your choice.

Before You Begin

Ensure to set up the following:

- A working Kubernetes cluster:
  - Your cluster must provide a StorageClass that is used to request Persistent Volumes. You must know the name of this storage class. For example, in Oracle Cloud Infrastructure Container Engine for Kubernetes (OKE), you can use the `oci-bv` storage class. The examples in this book use this `oci-bv` storage class.
  - The nodes in your cluster must have their clocks synchronized through NTP, or equivalent.

  Note

  For a list of supported Kubernetes releases, see the *Oracle TimesTen In-Memory Database Release Notes*.

- A development host to access the Kubernetes cluster. For this host, ensure the following:
  - The host resides outside the Kubernetes cluster.
  - You can control and access the Kubernetes cluster from this host.
  - You install the following command line tools on the host:
    * kubectl: You use `kubectl` to communicate with the Kubernetes cluster.
    * `docker` or `podman`: You use `docker` or `podman` when working with TimesTen container images on your local development host.

      Note

      The `podman` tool has a command that mimics `docker`. Examples in this guide use the `docker` command. See podman in the Podman documentation.

    * helm: You can use TimesTen Helm charts to deploy the TimesTen Kubernetes Operator and create TimesTen databases, If you plan on using TimesTen Helm charts, install the `helm` command line utility.

Let's run through a quick test to verify you have `docker` and `kubectl` pre-installed and configured on your development host.

1. On your development host, run `docker hello-world`.

   ```
   docker run hello-world
   ```

   The output is similar to the following:

   ```
   !... Hello Podman World ...!

            .--"--.
          / -     - \
         / (O)   (O) \
      ~~~| -=(,Y,)=- |
       .---. /`  \   |~~
    ~/  o  o \~~~~.----. ~~
     | =(X)= |~  / (O (O) \
      ~~~~~~~  ~| =(Y_)=-  |
     ~~~~    ~~~|   U      |~~

   Project:   https://github.com/containers/podman
   Website:   https://podman.io
   Desktop:   https://podman-desktop.io
   Documents: https://docs.podman.io
   YouTube:   https://youtube.com/@Podman
   X/Twitter: @Podman_io
   Mastodon:  @Podman_io@fosstodon.org
   ```

2. Confirm `kubectl` returns the nodes in your Kubernetes cluster.

   ```
   kubectl get nodes
   ```

   The output is similar to the following:

   ```
   NAME          STATUS   ROLES   AGE    VERSION
   192.0.2.1     Ready    node    32d    v1.27.2
   192.0.2.2     Ready    node    31d    v1.27.2
   192.0.2.4     Ready    node    101d   v1.27.2
   192.0.2.6     Ready    node    101d   v1.27.2
   192.0.2.10    Ready    node    32d    v1.27.2
   ```

Choose a TimesTen Container Image

As discussed in About TimesTen Container Images and Container Registry Options, you have several options for obtaining TimesTen container images for use in your Kubernetes environment. Choose one of the following options and complete the tasks for the option.

- Option 1: Use a Container Image from Oracle Container Registry
- Option 2: Use a Container Image from Oracle Cloud Marketplace
- Option 3: Build a Container Image and Push It to a Container Registry of Your Choice

Option 1: Use a Container Image from Oracle Container Registry

Here are the tasks to use a TimesTen container image from Oracle Container Registry:

- Create Auth Token
- Accept the Oracle License Agreement
- Configure Your Development Host and Kubernetes Cluster

Create Auth Token

1. From a web browser, log in to the Oracle Container Registry web interface using your Oracle account.
2. In the upper right hand corner next to your **Oracle login**, expand the **down arrow**, and choose **Auth Token**.
3. On the **Auth Token** page, choose **Generate Key**.
4. Copy and save the generated key (auth token) in a safe location. You need it later.

Accept the Oracle License Agreement

1. If you are not already on Oracle Container Registry, log in to the Oracle Container Registry web interface using your Oracle account.
2. From the TimesTen Repositories page, in the **Repository** column, choose the **timesten** repository. The `timesten` repository contains container images for running TimesTen.
3. Accept the Oracle license agreement. Complete this step only if you choose container images in the `timesten` repository. Since TimesTen is a licensed Oracle product, you must accept the Oracle license agreement to use a container image in this repository. You only need to complete this step once.
   a. On the **Official container images for the Oracle TimesTen In-Memory Database** page, to the right of the **Quick Reference Description**, locate the **Select Language** drop down list. In the **Select Language** drop down list, choose **your language.** Then, review the text before the **Continue** button and click **Continue**.

      The text that is displayed before the **Continue** button is similar to the following: "You must agree to and accept the *Oracle Standard Terms and Restrictions* prior to downloading from the Oracle Container Registry. Please read the license agreement on the following page carefully."
   b. On the **Oracle Standard Terms and Restrictions** page, review the information on the page, then at the bottom of the page, click **Accept**.

   The **Official container images for the Oracle TimesTen In-Memory Database** page displays for a second time. To the right of the **Quick Reference Description**, look for a **green check mark** with text similar to the following: "You last accepted the Oracle Standard Terms and Restrictions on 01/08/2025 at 01:28 PM Coordinated Universal Time (UTC)."
4. Choose a TimesTen container image.

   On either the `timesten` or `timesten-xe` repository page, scroll through the list of container images to identify a TimesTen container image that you want to use for deploying the TimesTen Kubernetes Operator in your Kubernetes cluster.

   For example, let's choose `container-registry.oracle.com/timesten/timesten:26.1.1.1.0`.

Here's a summary sheet of the information obtained. Save it for future reference.

Item	Example
Your Oracle Container Registry user name	`john.smith@example.com`
Generated auth token	`z1SbLO4JgwqzLEn1ZxJ`
Container image	`container-registry.oracle.com/timesten/timesten:26.1.1.1.0`

Configure Your Development Host and Kubernetes Cluster

1. On your development host, use the `docker login` command to log in to Oracle Container Registry.

   ```
   docker login container-registry.oracle.com
   ```

   At the prompt, enter the following:

   - `username`: Enter the username you use to sign in to the Oracle Container Registry web interface. This example uses `john.smith@example.com`.
   - `password`: Enter the auth token you previously generated and saved.

   ```
   Username: john.smith@example.com
   Password: auth token
   Login Succeeded!
   ```

   If you are using `docker`, the `docker login` operation creates or updates the `$HOME/.docker/config.json` file with the auth token you provided when you were prompted for your password. You now can use `docker` to access and pull TimesTen container images from Oracle Container Registry to your local development host.

   If you are using `podman`, the credentials may be stored in a different location. See https://docs.podman.io/en/v4.3/markdown/podman-login.1.html.

2. (Optional): Confirm the credentials are stored in the `config.json` file. This example assumes the credentials are located in `$HOME/.docker/config.json`.

   ```
   cat $HOME/.docker/config.json
   ```

   The output contains the auth token for `container-registry.oracle.com`.

   ```
   {
           "auths": {
                   "container-registry.oracle.com": {
                           "auth": "z1SbLO4JgwqzLEn1ZxJ"}

                    }
   }
   ```

3. Pull the TimesTen container image from Oracle Container Registry.

   ```
   docker pull container-registry.oracle.com/timesten/timesten:26.1.1.1.0
   ```

4. Create the image pull secret. This example creates the `sekret` secret. You can use any name.

   ```
   kubectl create secret generic sekret \
   --from-file=.dockerconfigjson=$HOME/.docker/config.json \
   --type=kubernetes.io/dockerconfigjson
   ```

5. (Optional): Confirm the Secret is created in your Kubernetes cluster.

   ```
   kubectl get secrets
   NAME                                TYPE                             DATA
   AGE
   sekret                              kubernetes.io/dockerconfigjson   1
   1d
   ```

   For more information, see Pulling Images from Registry during Deployment in the Kubernetes documentation.

6. Save the name of the image pull secret. You need it later.

Congratulations! You obtained a TimesTen container image from Oracle Container Registry.

Next Steps

Proceed to Obtain TimesTen YAML Manifest Files and Helm Charts.

Option 2: Use a Container Image from Oracle Cloud Marketplace

See Introduction in the *Oracle TimesTen In-Memory Database Using Oracle Cloud Marketplace to Obtain a TimesTen Container Image (BYOL)* guide.

Option 3: Build a Container Image and Push It to a Container Registry of Your Choice

Here are the tasks to build a TimesTen container image and push it to a registry of your choice:

- Configure Your Development Host and Kubernetes Cluster
- Download and Unpack a TimesTen Distribution
- Build a TimesTen Container Image
- Tag and Push the Container Image to Your Container Registry

Configure Your Development Host and Kubernetes Cluster

Let's choose `container-registry.visioncorp.com/repo` for the registry and repository of your choice.

1. On your development host, use the `docker login` command to log in to your `container-registry.visioncorp.com` container registry. At the prompt, enter your credentials for your container registry.

   ```
   docker login container-registry.visioncorp.com
   ```

If you are using `docker`, the `docker login` operation creates or updates the `$HOME/.docker/config.json` file with the auth token you provided when you were prompted for your password.

If you are using `podman`, the credentials may be stored in a different location. See https://docs.podman.io/en/v4.3/markdown/podman-login.1.html

2. On your development host, create an image pull secret.

   A Kubernetes Secret takes a copy of your credentials from the `docker login` command and makes them available to your Kubernetes cluster.

   This example creates a Secret called `sekret`. You can use any name.

   ```
   kubectl create secret generic sekret \
   --from-file=.dockerconfigjson=$HOME/.docker/config.json \
   --type=kubernetes.io/dockerconfigjson
   ```

   For more information, see Pulling Images from Registry during Deployment in the Kubernetes documentation.

3. Save the name of the image pull secret. You need it later.

Download and Unpack a TimesTen Distribution

1. Download a TimesTen distribution to a *`download_location`*.
2. On your development host, from the directory of your choice:
   - Create one subdirectory for the TimesTen distribution. This example creates the *`installation_dir`* subdirectory.
   - Create a second subdirectory for the TimesTen Operator distribution. This example creates the *`kube_files`* subdirectory.

   ```
   mkdir -p installation_dir
   mkdir -p kube_files
   ```

3. Change to the TimesTen distribution subdirectory. Next, copy the TimesTen distribution that you previously downloaded into this subdirectory.

   ```
   cd installation_dir
   cp download_location/timesten261110.server.linux8664.zip .
   ```

4. Unpack the TimesTen distribution.

   ```
   unzip timesten261110.server.linux8664.zip
   ```

   The output is similar to the following:

   ```
   Archive:  timesten261110.server.linux8664.zip
      creating: tt26.1.1.1.0/
      ...
      creating: tt26.1.1.1.0/kubernetes/
    extracting: tt26.1.1.1.0/kubernetes/operator.zip
   ...
   ```

The TimesTen Kubernetes Operator distribution is `installation_dir/tt26.1.1.1.0/kubernetes/operator.zip`.

> **Note**
>
> Do not delete the TimesTen distribution. You need it later.

5. Change to the TimesTen Kubernetes Operator subdirectory you created in a previous step. (In this example, *kube_files*.) Next, unpack the TimesTen Kubernetes Operator distribution.

   ```
   cd kube_files
   unzip installation_dir/tt26.1.1.1.0/kubernetes/operator.zip
   ```

   The output is similar to the following:

   ```
   Archive:  installation_dir/tt26.1.1.1.0/kubernetes/operator.zip
      ...
      creating: helm/
      creating: helm/ttclassic/
      ...
      creating: helm/ttcrd/
      ...
      creating: helm/ttoperator/
      ...
      creating: deploy/
     inflating: deploy/crd.yaml
     inflating: deploy/service_account.yaml
     inflating: deploy/service_account_cluster.yaml
     inflating: deploy/operator.yaml
      creating: image/
     inflating: image/Dockerfile
      creating: operator/
     ...
   ```

Build a TimesTen Container Image

TimesTen provides the files you need to build a TimesTen container image in its TimesTen Kubernetes Operator distribution. In this example, the directory that contains the unzipped TimesTen Kubernetes Operator distribution is `kube_files`.

1. On your development host, change to the `image` directory of the unzipped TimesTen Kubernetes Operator distribution (`kube_files/image`, in this example).

   ```
   cd kube_files/image
   ```

2. Copy the TimesTen distribution into the directory. In a previous example, you created the *installation_dir* directory. This directory contains the TimesTen distribution.

   ```
   cp installation_dir/timesten261110.server.linux8664.zip .
   ```

3. On your development host, change to the `kube_files/image` directory if you are not in that directory. Next, use the `docker build` command to build a TimesTen container image.

This example specifies the following Dockerfile ARGs on the command line.

- `TT_DISTRO`: The name of the file containing the TimesTen distribution (`timesten261110.server.linux8664.zip`, in this example).
- `TT_RELEASE`: The name of the TimesTen release in dotted format (`26.1.1.1.0`, in this example).

```
docker build -t ttimage:26.1.1.1.0 \
--build-arg TT_DISTRO=timesten2211250.server.linux8664.zip \
--build-arg TT_RELEASE=26.1.1.1.0 .
```

The build process starts. When completed, output similar to the following displays:

```
Successfully tagged ttimage:26.1.1.1.0
```

The name of the container image is `ttimage:26.1.1.1.0`.

4. Save the name of the container image. You need it later.

Congratulations! You successfully built a TimesTen container image.

Tag and Push the Container Image to Your Container Registry

Let's use the container image you built in Build a TimesTen Container Image. In the example, the name of the image is `ttimage:26.1.1.1.0`.

1. On your development host, tag the TimesTen container image.

```
docker tag ttimage:26.1.1.1.0 container-registry.visioncorp.com/
repo:ttimage26.1.1.1.0
```

2. Push the TimesTen container image to your container registry.

```
docker push container-registry.visioncorp.com/repo:ttimage26.1.1.1.0
```

Note

To reduce the size of the final TimesTen container image, the Dockerfile uses a multi-stage build. This results in a dangling image left behind. To locate dangling images, use the `docker` command with the `-f` filter flag with a value of `dangling=true`. Once you locate the dangling image, you can use the `docker image prune` command to remove it. This example removes all dangling images.

```
docker images -f dangling=true
docker image prune
```

Congratulations! You successfully tagged and pushed a TimesTen container image to a registry of your choice.

Next Steps

Proceed to Obtain TimesTen YAML Manifest Files and Helm Charts.

Obtain TimesTen YAML Manifest Files and Helm Charts

TimesTen provides YAML manifest files and Helm charts in TimesTen container images. You use these files and charts to install the TimesTen Operator and create TimesTen databases in your Kubernetes cluster.

Now that you have completed the tasks to obtain and use a TimesTen container image in your Kubernetes environment, you can use this container image to obtain TimesTen YAML manifest files and Helm charts. To do so, you create a container from the container image and copy the TimesTen YAML manifest files and Helm charts from the container to a location on your development host.

In this example, let's use a container image located on Oracle Container Registry. If you are using a container image in another location, use it instead. Let's walk through the steps to copy the TimesTen YAML manifest files and Helm charts from this container image to a directory on your development host. This example uses `container-registry.oracle.com/timesten/timesten:26.1.1.1.0`.

1. On your development host, from a directory of your choice, create a subdirectory for the TimesTen YAML manifest files and Helm charts. This example creates the `kube_files` subdirectory.

   ```
   mkdir -p kube_files
   ```

2. Create a new container from the `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` image, supplying a name for the new container. In this example, the name of the container is `ttoper`.

   ```
   docker create --name ttoper container-registry.oracle.com/timesten/
   timesten:26.1.1.1.0
   ```

3. Copy the YAML manifest files and Helm charts from the `ttoper` container to the `kube_files` directory on your development host. The `ttoper:/timesten/operator/deploy` directory contains the YAML manifest files and the `ttoper:/timesten/operator/helm` directory contains the Helm charts.

   ```
   docker cp ttoper:/timesten/operator/deploy kube_files
   docker cp ttoper:/timesten/operator/helm kube_files
   ```

   Verify the directories exist on your development host.

   ```
   ls kube_files/*
   ```

   The output is the following:

   ```
   kube_files/deploy:
   crd.yaml  operator.yaml  service_account.yaml service_account_cluster.yaml

   kube_files/helm:
   ttclassic  ttcrd  ttoperator
   ```

The `deploy` directory contains the TimesTen YAML manifest files and the `helm` directory contains the TimesTen Helm charts. You use these files later to deploy the TimesTen Operator and create TimesTen databases.

4. Remove the `ttoper` container.

   ```
   docker rm ttoper
   ```

5. Remove the TimesTen container image.

   ```
   docker image rm container-registry.oracle.com/timesten/timesten:26.1.1.1.0
   ```

Congratulations! You successfully obtained the TimesTen YAML manifest files and Helm charts.

Next Steps

You are now ready to install the TimesTen Custom Resource Definitions (CRDs). See the next chapter Install the TimesTenClassic Custom Resource Definition.

3

Install the TimesTenClassic Custom Resource Definition

Learn about the TimesTenClassic Custom Resource Definition (CRD) and how to install it.

Topics:

- About the TimesTenClassic CRD
- Install the TimesTenClassic CRD

About the TimesTenClassic CRD

Kubernetes operates on objects of various built-in object types, including Pods, Services, and StatefulSets. One way to extend Kubernetes is with CRDs. CRDs define new object types to Kubernetes. Once installed, Kubernetes understands these object types just like it understands Pods, Services, StatefulSets, and all other built-in object types.

The TimesTen Kubernetes Operator (TimesTen Operator) provides a CRD called TimesTenClassic. The TimesTenClassic CRD defines the attributes and metadata for TimesTen databases.

The CRD definition, including the object type and its set of attributes, is referred to as a schema.

Kubernetes supports CRD versioning whereby different versions of the same CRD are supported simultaneously and each version can provide a different schema. This enables the attributes of a CRD to be extended from release to release.

The TimesTen Operator provides different versions of the TimesTenClassic CRD. The v4 schema version is the most current. It provides the attributes of the v4 schema version plus additional attributes specific to the latest release of the TimesTen Operator. When defining new TimesTenClassic objects, use the v4 schema version. The v4 and v3 schema versions are available to facilitate compatibility with previous releases of the TimesTen Operator. No additional changes are made to these schema versions.

Note

The v3 schema version is deprecated. It is fully supported in this release. However, it will be removed in a future release.

For more information about the TimesTenClassic CRD, see Syntax for the TimesTenClassic Object Type.

Install the TimesTenClassic CRD

CRDs are cluster-scoped. When you install the TimesTenClassic CRD in your Kubernetes cluster, the installation affects all namespaces within the cluster.

Let's walk-through an example showing you how to install the TimesTenClassic CRD using a TimesTen YAML manifest file. If you want to use TimesTen Helm charts, see Use Helm in Your TimesTen Kubernetes Operator Environment.

Before you begin the following steps, ensure you complete the tasks in Prepare to Use the TimesTen Kubernetes Operator. After completing the tasks, the TimesTen YAML manifest files and Helm charts reside in a location on your development host. In this example, the location is `kube_files/deploy`.

1. On your development host, change to the *`kube_files`*`/deploy` directory.

   ```
   cd kube_files/deploy
   ```

2. Install the TimesTenClassic CRD.

   ```
   kubectl create -f crd.yaml
   ```

   The output is the following:

   ```
   customresourcedefinition.apiextensions.k8s.io/
   timestenclassics.timesten.oracle.com created
   ```

3. Verify installation.

   ```
   kubectl get crds | grep timesten
   ```

   The output is similar to the following:

   ```
   timestenclassics.timesten.oracle.com
   2025-10-14T01:46:23Z
   ```

Congratulations! You successfully installed the TimesTenClassic CRD. You are now ready to install the TimesTen Kubernetes Operator. Proceed to Learn About and Install the TimesTen Kubernetes Operator.

4
Learn About and Install the TimesTen Kubernetes Operator

The TimesTen Kubernetes Operator (TimesTen Operator) creates, manages, and monitors TimesTenClassic objects (and associated databases) in your Kubernetes environment. Let's learn about the TimesTen Operator and walk through the steps to install it.

Topics:

About Kubernetes Operators

Kubernetes Operators monitor a Kubernetes cluster for the creation of objects of specified types. When you create an object of a supported type, a Kubernetes Operator takes action to implement the object. Kubernetes Operators can be namespace-scoped or cluster-scoped. Namespace-scoped Operators monitor a Kubernetes cluster looking for supported objects in the namespace in which the Operator is running whereas cluster-scoped Operators monitor a Kubernetes cluster looking for supported objects in any namespace in the cluster.

TimesTen provides a customized Kubernetes Operator called the TimesTen Kubernetes Operator.

About the TimesTen Operator

The TimesTen Operator is an application that functions like a human operator. It creates, monitors, and manages TimesTen databases in a Kubernetes cluster. It configures a database, configures the database's users and schema, and if applicable, configures cache and replication. The TimesTen Operator automatically manages and monitors the health of TimesTen databases and takes action to fix problems. For example, in an active standby pair replication scheme, if the active database fails, the TimesTen Operator takes automatic action by promoting the standby to the new active. Kubernetes replaces the failed Pod that contains the active database. The TimesTen Operator brings TimesTen back up as the new standby in this replaced Pod. The TimesTen Operator performs these operations automatically and there is no human intervention needed. This TimesTen Operator can create and manage many TimesTen databases simultaneously.

You can install the TimesTen Operator in either of the following ways:

- In one or more namespaces in your Kubernetes cluster at namespace-scope (namespace-scoped).
- In the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope (cluster-scoped). The `timesten-operator` namespace is non-configurable and is reserved for internal use. This namespace is explained in later sections.

You have the option of deciding which is best. Let's look at these options in further detail.

- If you install the TimesTen Operator in a namespace in your Kubernetes cluster at namespace-scope, you can then create TimesTenClassic objects in that same namespace. The TimesTen Operator provisions Pods, Services, and other Kubernetes resources necessary to deploy TimesTen databases in this same namespace. If you want to deploy TimesTen databases in multiple namespaces, you must install multiple copies of the TimesTen Operator, one in each namespace. While this adds complexity, it also adds flexibility. For example, since it is possible to run different versions of the TimesTen Operator in each namespace, test and production environments can share a single cluster.
- If you install the TimesTen Operator in a Kubernetes cluster at cluster-scope, a new namespace called `timesten-operator` is created in the cluster. The TimesTen Operator runs in this `timesten-operator` namespace. All other namespaces in the Kubernetes cluster can create TimesTenClassic objects. These objects are handled by this TimesTen Operator. The Pods, Services, and other Kubernetes resources that are used to provision these databases reside in the namespace of the associated TimesTenClassic object. Since there is only one TimesTen Operator that manages all TimesTenClassic objects, this option adds a less complex environment. However, this environment is less flexible. For example, there can only be one version of the TimesTen Operator, so test and production environments may not be able to share a single cluster if these environments require different versions of the TimesTen Operator.

Note

The `timesten-operator` namespace is reserved for internal use. You must not run anything in the `timesten-operator` namespace. In addition, you must create TimesTenClassic objects in your own namespaces.

Regardless of which scope you use, when you create a TimesTenClassic object in a namespace (`X`, for example), any references to other Kubernetes objects included in that object also refer to objects in namespace `X`. This includes `dbConfigMap`, `dbSecret`, `imagePullSecret`, and all other object references. A TimesTenClassic object in namespace `X` cannot refer to such objects in other namespaces.

About Deploying in a Multi-Architecture Kubernetes Cluster

Kubernetes supports single architecture and multi-architecture clusters. A single architecture cluster is a cluster in which nodes within the cluster use the same computer instruction set. For example, a single-architecture cluster could consist of all `arm64` nodes or all `amd64` nodes. A multi-architecture cluster is a Kubernetes cluster in which nodes within the cluster may be of different computer instruction sets. For example, a multi-architecture cluster could consist of both `amd64` and `arm64` nodes.

The TimesTen Operator runs in single and multi-architecture Kubernetes clusters. Pods that are created by the TimesTen Operator run on nodes of the same node type as the TimesTen Operator. For example, if the TimesTen Operator runs on `amd64` nodes, Pods created by this TimesTen Operator also run on `amd64` nodes.

If you are running the TimesTen Operator in a namespace-scoped environment, you can deploy the TimesTen Operator in one namespace on `arm64` nodes (and have it provision and manage TimesTen on `arm64` nodes) and you can deploy a second TimesTen Operator in a different namespace on `amd64` nodes (and have it provision and manage TimesTen on `amd64` nodes). However, if you are running the TimesTen Operator in a cluster-scoped environment, you must use the same node type. For more information about namespace-scoped and cluster-scoped Operators, see About Kubernetes Operators and About the TimesTen Operator.

The `affinity` settings of both the TimesTen Operator YAML manifest files and the TimesTen Operator helm charts control whether the Operator and the objects it manages uses `arm64` or `amd64` nodes. For example, here is a snippet of the `affinity` section of a TimesTen Operator YAML manifest file:

```
# An example affinity definition; this pod will only be assigned to a node
# running on amd64 (the default)
#
#     affinity:
#       nodeAffinity:
#         requiredDuringSchedulingIgnoredDuringExecution:
#           nodeSelectorTerms:
#             - matchExpressions:
#               - key: "kubernetes.io/arch"
#                 operator: In
#                 values: ["amd64"]
...
```

If your Kubernetes cluster consists of a single architecture, you do not need to change the `affinity` section. However, if you are using a multi-architecture cluster, you must instruct Kubernetes to deploy the TimesTen Operator on a specific architecture. Here's how:

- Uncomment the `.affinity.nodeAffinity` section.
- In the `.affinity.nodeAffinity.nodeSelectorTerms` section where `key` has the value `"kubernetes-io/arch"`, specify either `"amd64"` or `"arm64"` for `values`.

For example, to instruct Kubernetes to deploy the TimesTen Operator and the objects it manages on `amd64` nodes, do the following:

```
# An example affinity definition; this pod will only be assigned to a node
# running on amd64 (the default)
#
      affinity:
       nodeAffinity:
         requiredDuringSchedulingIgnoredDuringExecution:
           nodeSelectorTerms:
             - matchExpressions:
               - key: "kubernetes.io/arch"
                 operator: In
                 values: ["amd64"]
...
```

Valid values are as follows:

- `"amd64"`: Use this for TimesTen Operators that you want to run on `amd64` nodes.
- `"arm64"`: Use this for TimesTen Operators that you want to run on `arm64` nodes.

About the Default Kubernetes Security Context for the TimesTen Operator

A Kubernetes security context defines privilege and access control settings for a Pod or Container. There are several security context settings. See Configure a Security Context for a Pod or Container in the Kubernetes documentation.

The TimesTen Operator runs with a default security context and includes the Kubernetes default seccomp profile.

The following snippet shows the default security context for the TimesTen Operator.

```
securityContext:
  allowPrivilegeEscalation: false
  capabilities:
    drop:
    - ALL
  privileged: false
  readOnlyRootFilesystem: true
  runAsNonRoot: true
  seccompProfile:
    type: RuntimeDefault
```

About Readiness and Liveness Probes

The TimesTen Operator provides readiness and liveness probes so that Kubernetes can determine the health of the TimesTen Operator.

The TimesTen Operator exposes these probes to applications in the Kubernetes cluster by creating a Kubernetes Service called `timesten-operator`. Although we do not recommend it, you can choose to not expose these probes by setting the TimesTen Operator `EXPOSE_PROBES` environment variable to `"0"` or by modifying the TimesTen Operator helm charts.

For information about the TimesTen Operator environment variables, see TimesTen Kubernetes Operator Environment Variables. For information about helm charts, see Use Helm in Your TimesTen Kubernetes Operator Environment.

About Privileges

The TimesTen Operator needs different privileges depending on whether you install the TimesTen Operator at namespace-scoped or at cluster-scoped.

- When the TimesTen Operator runs in a namespace in your cluster at namespace-scope, it only needs privileges within the namespace where you installed it. The TimesTen Operator does not require privileges in any other namespace in the cluster.
- When the TimesTen Operator runs in the `timesten-operator` namespace in your cluster at cluster-scope, it needs privileges within the namespace it runs in as well as in every namespace in the cluster.

Kubernetes uses Roles and RoleBindings to specify privileges within a single namespace and uses ClusterRoles and ClusterRoleBindings to specify privileges across all namespaces. For more information about Kubernetes Roles, RoleBindings, ClusterRoles, and

ClusterRoleBindings, see https://kubernetes.io/docs/reference/access-authn-authz/rbac/ in the Kubernetes documentation.

When the TimesTen Operator runs at namespace-scope, it requires Roles and RoleBindings to operate. Specifically, when you install the TimesTen Operator in a namespace at namespace-scope, a ServiceAccount called `timesten-operator` is created in this namespace and a RoleBinding is created and used to give the `timesten-operator` service account the necessary privileges. These privileges are defined in the `timesten-operator` Role.

When the TimesTen Operator runs at cluster-scope, it requires Roles, RoleBindings, ClusterRoles, and ClusterRoleBindings to operate. Since the TimesTen Operator needs privileges in every namespace and needs additional privileges just in its namespace, the following objects are provisioned:

- ClusterRole called `timesten-operator`: Defines the privileges that the TimesTen Operator requires in each namespace in the cluster.
- ClusterRoleBinding called `timesten-operator`: Gives the `timesten-operator` service account in the `timesten-operator` namespace the privileges in the `timesten-operator` cluster role.
- Namespace `timesten-operator`: Is the namespace in which the TimesTen Operator runs. This namespace is non-configurable. In this namespace, the following objects are created:
  - ServiceAccount called `timesten-operator`: The TimesTen Operator runs with the privileges of this service account.
  - Role called `timesten-operator`: Defines the privileges the TimesTen Operator requires in the `timesten-operator` namespace.
  - RoleBinding called `timesten-operator`: Gives the `timesten-operator` service account in the `timesten-operator` namespace the privileges in the `timesten-operator` role.

In summary, when you install the TimesTen Operator in a namespace in your cluster at namespace-scope, a ServiceAccount called `timesten-operator` is created in that namespace and a RoleBinding is used to give the service account the necessary privileges. In contrast, when you install the TimesTen Operator in your cluster at cluster-scope, the `timesten-operator` namespace is created. In addition, a ServiceAccount is created in this `timesten-operator` namespace and RoleBindings and ClusterRoleBindings are used to give the service account the necessary privileges. There are examples later in the chapter that illustrate the creation of these objects.

About Installing the TimesTen Operator

There are YAML manifest files and Helm charts for installing the TimesTen Operator. A TimesTen container image contains these files and charts. To find out how to obtain these files and charts, see Obtain TimesTen YAML Manifest Files and Helm Charts.

The YAML manifest files and Helm charts for installing the TimesTen Operator in a namespace in your Kubernetes cluster at namespace-scope are different than the files for installing the TimesTen Operator in the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope. For information about these scopes, see About the TimesTen Operator.

Note

You must install the TimesTen Operator in either one or more namespaces in your cluster at namespace-scope or in the `timesten-operator` namespace in your cluster at cluster-scope. You cannot install in both scopes.

To install the TimesTen Operator in a namespace in your Kubernetes cluster at namespace-scope, you can use either YAML manifest files or a Helm chart:

- To install using YAML manifest files, use the following files:
  - `service_account.yaml`: Defines the RoleBinding, Role, and ServiceAccount objects that are necessary for the TimesTen Operator to run properly in a namespace in your cluster at namespace-scope. The service account requires a set of defined privileges and permissions, which are granted through a role. A role binding assigns a role to a service account. See About Privileges.
  - `service_account_cluster.yaml`: Defines additional privileges and permissions for the TimesTen Operator. Although not mandatory, we recommend that you install this file. It defines the privileges and permissions that are required if you want the TimesTen Operator to delete TimesTen Pods and PVCs when detecting a node failure. For more information about this feature, see How the TimesTen Kubernetes Operator Handles Node Failure.
  - `operator.yaml`: Defines the Deployment that is used to run the TimesTen Operator in a namespace in your cluster at namespace-scope. There are customizations for this Deployment. See About Customizations for a TimesTen Operator Deployment.
- To install using a Helm chart, use the `ttoperator` Helm chart. See Use Helm in Your TimesTen Kubernetes Operator Environment and The ttoperator Chart.

To install the TimesTen Operator in the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope, you can use either YAML manifest files or a Helm chart:

- To install using YAML manifest files, use the following files:
  - `cluster_config.yaml`: Defines the `timesten-operator` namespace as well as the ServiceAccount, Role, RoleBinding, ClusterRole, and ClusterRoleBinding objects necessary to run the TimesTen Operator in the `timesten-operator` namespace at cluster-scope. For more information about these objects, see About Privileges.
  - `cluster_operator.yaml`: Defines the Deployment that is used to run the TimesTen Operator in the `timesten-operator` namespace in your cluster at cluster-scope. There are customizations for this Deployment. See About Customizations for a TimesTen Operator Deployment.
- To install using a Helm chart, use the `ttclusteroperator` Helm chart. See Use Helm in Your TimesTen Kubernetes Operator Environment and The ttclusteroperator Chart.

There are examples in this chapter that show you how to install the TimesTen Operator in a namespace in your Kubernetes cluster at namespace-scope and in the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope using YAML manifest files. To install using Helm charts, see Use Helm in Your TimesTen Kubernetes Operator Environment.

Note

Most of the examples in the book assume you have installed the TimesTen Operator in a namespace in your Kubernetes cluster at namespace-scope. If there are cases where the TimesTen Operator is installed in the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope, the documentation points this out.

About Customizations for a TimesTen Operator Deployment

The `operator.yaml` YAML file defines the Deployment to run the TimesTen Operator in a namespace-scoped environment and the `cluster_operator.yaml` YAML file defines the Deployment to run the TimesTen Operator in a cluster-scoped environment. These files provide customizations that you can make for your specific environment. The customizations that you can make are the same for namespace-scoped and cluster-scoped ennvironments.

The `ttoperator` and `ttclusteroperator` Helm charts define the TimesTen Operator deployments using Helm. If you are using Helm, see Use Helm in Your TimesTen Kubernetes Operator Environment.

The following information is specific to YAML manifest files:

To customize the TimesTen Operator, modify either the `operator.yaml` or `cluster_operator.yaml` file (modify `operator.yaml` for namespace-scoped environments or `cluster_operator.yaml` for cluster-scoped environments). The modifications are as follows:

- `image`: Container image to run.
- `imagePullSecrets`: Image pull secret that contains the credentials to access the image registry for the `image`.
- `replicas`: Number of TimesTen Operator Pods to run.
- `affinity`: Section that allows you to define whether the TimesTen Operator runs on `amd64` or `arm64` Nodes. These Node settings are specific to running in a multi-architecture Kubernetes environment. See About Deploying in a Multi-Architecture Kubernetes Cluster.
- Environment variables for the TimesTen Operator. Even though we recommend that you do not change the default settings, these are the environment variables that are customizable if you so choose:
  - `CREATE_SERVICEMONITOR`: See Expose Metrics from the TimesTen Kubernetes Operator.
  - `EXPOSE_METRICS`: See Expose Metrics from the TimesTen Kubernetes Operator.
  - `EXPOSE_PROBES`: See About Readiness and Liveness Probes.
  - `METRICS_SCHEME`: See Expose Metrics from the TimesTen Kubernetes Operator.
  - `TT_MAX_RECONCILES`: See TimesTen Kubernetes Operator Environment Variables.

  For more information about the TimesTen Operator environment variables, see TimesTen Kubernetes Operator Environment Variables.

Install the TimesTen Operator

Let's walk through some examples that show you how to install the TimesTen Operator in two namespaces in a Kubernetes cluster at namespace-scope and in the `timesten-operator` namespace in a Kubernetes cluster at cluster-scope. These examples assume you are using YAML manifest files. If you are using Helm charts, see Use Helm in Your TimesTen Kubernetes Operator Environment.

- Install the TimesTen Operator at Namespace-Scope
- Install the TimesTen Operator at Cluster-Scope

Install the TimesTen Operator at Namespace-Scope

The examples in this section assume you have obtained the YAML manifest files. See Obtain TimesTen YAML Manifest Files and Helm Charts.

There is one example for installing the TimesTen Operator in one namespace in your cluster at namespace-scope. There is a second example for installing the TimesTen Operator into a second namespace in your cluster at namespace-scope. The examples illustrate that you must install the TimesTen Operator in each namespace. Once installed, the TimesTen Operator that you installed in namespace one services TimesTenClassic objects in namespace one while the TimesTen Operator that you installed in namespace two services TimesTenClassic objects in namespace two.

To complete the installation, perform the steps in the following sections:

- Before You Begin
- Install in Namespace One
- Install in Namespace Two
- Verify Installation

Before You Begin

Let's confirm our current namespace in the Kubernetes cluster. Next, let's create a new namespace and a new Kubernetes Secret in that namespace. The examples use these two namespaces.

1. Confirm the current namespace and review the Secrets in the namespace.
   a. Confirm the current namespace.

      ```
      kubectl config view | grep namespace
      ```

      The output is similar to the following:

      ```
          namespace: mynamespace
      ```

      The current namespace is `mynamespace`.
   b. Confirm the Secret in the namespace.

      ```
      kubectl get secrets
      ```

      The output is similar to the following:

      ```
      NAME
      TYPE                              DATA   AGE
      ...
      sekret
      kubernetes.io/dockerconfigjson   1      15d
      ...
      ```

      The `sekret` Secret exists in the `mynamespace` namespace.

2. Create a new namespace and create a Kubernetes Secret in the namespace.
   a. Create a new namespace.

      ```
      kubectl create namespace mynamespace2
      ```

      The output is similar to the following:

      ```
      namespace/mynamespace2 created
      ```

   b. Switch to the new namespace.

      ```
      kubectl config set-context --current --namespace=mynamespace2
      ```

      The output is similar to the following:

      ```
      Context "default" modified.
      ```

   c. Confirm the current namespace.

      ```
      kubectl config view | grep namespace
      ```

      The output is similar to the following:

      ```
          namespace: mynamespace2
      ```

   d. Create a Kubernetes Secret in this namespace.

      ```
      kubectl create secret generic sekret --from-
      file=.dockerconfigjson=$HOME/.docker/config.json --type=kubernetes.io/
      dockerconfigjson
      ```

      The output is the following:

      ```
      secret/sekret created
      ```

3. Confirm the namespaces.

   ```
   kubectl get namespaces
   ```

   The output is similar to the following:

   ```
   NAME                  STATUS    AGE
   mynamespace           Active    15d
   ...
   mynamespace2          Active    49m
   ```

You confirmed the namespaces in your Kubernetes cluster.

Install in Namespace One

Let's install the TimesTen Operator in a namespace called `mynamespace` in your Kubernetes cluster at namespace-scoped.

1. Switch to namespace one (`mynamespace`, in this example).

   ```
   kubectl config set-context --current --namespace=mynamespace
   ```

   The output is similar to the following:

   ```
   Context "default" modified.
   ```

2. Change to the directory that contains the YAML manifest files. In this example, the `kube_files/deploy` contains the files.

   ```
   cd kube_files/deploy
   ```

3. Install the required service account, role, and role binding.

   ```
   kubectl create -f service_account.yaml
   ```

   The output is similar to the following:

   ```
   role.rbac.authorization.k8s.io/timesten-operator created
   serviceaccount/timesten-operator created
   rolebinding.rbac.authorization.k8s.io/timesten-operator created
   ```

4. Make a copy of the `service_account_cluster.yaml` file for the first namespace (`service_account_cluster_n1.yaml`, in this example).

   ```
   cp service_account_cluster.yaml service_account_cluster_n1.yaml
   ```

5. Install the `service_account_cluster_n1.yaml` YAML file by doing the following:

   a. (Optional): Display the contents of the `service_account_cluster_n1.yaml` file.

      ```
      cat service_account_cluster_n1.yaml
      ```

      The output is similar to the following:

      ```
      # Copyright (c) 2025, Oracle and/or its affiliates.
      apiVersion: rbac.authorization.k8s.io/v1
      kind: ClusterRole
      metadata:
        name: timesten-operator
        # If running multiple operators on the same cluster:
        #name: timesten-operator-<NAMESPACE>
      rules:
      - apiGroups:
        - ""
        resources:
        - nodes
      ```

```
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - persistentvolumeclaims
  verbs:
  - get
  - list
  - watch
  - delete
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
subjects:
- kind: ServiceAccount
  name: timesten-operator
  #namespace: <NAMESPACE>
roleRef:
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
  apiGroup: rbac.authorization.k8s.io
```

b. Use a text editor to modify the `service_account_cluster_n1.yaml` file.

   Make the following changes:

   - Locate `#namespace`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace`, in this example).
   - Locate the three occurrences of `#name`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace`, in this example).

```
vi service_account_cluster_n1.yaml

# Copyright (c) 2025, Oracle and/or its affiliates.
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace
rules:
- apiGroups:
  - ""
  resources:
  - nodes
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - persistentvolumeclaims
  verbs:
  - get
  - list
  - watch
  - delete
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace
subjects:
- kind: ServiceAccount
  name: timesten-operator
  namespace: mynamespace
roleRef:
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace
  apiGroup: rbac.authorization.k8s.io
```

c. Save and close the `service_account_cluster_n1.yaml` file.

d. Install the `service_account_cluster_n1.yaml` file.

```
kubectl create -f service_account_cluster_n1.yaml
```

The output is similar to the following:

```
clusterrole.rbac.authorization.k8s.io/timesten-operator created
clusterrolebinding.rbac.authorization.k8s.io/timesten-operator created
```

6. Modify the `operator.yaml` file by doing the following:

   a. Use a text editor to modify the `operator.yaml` file.

   Replace the following:

   - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` with the name of your image. In this example, the name of the image is `container-registry.oracle.com/timesten/timesten:26.1.1.1.0`.
   - `imagePullSecrets`: Replace `sekret` with the name of your image pull secret. In this example, the name of the image pull secret is `sekret`.

- If you are running in a multi-architecture environment, modify the `affinity` section, and specify either `amd64` or `arm64`. This example assumes you are running in a multi-architecture environment and sets nodes to `amd64`.

```
vi operator.yaml

# Copyright (c) 2019 - 2025, Oracle and/or its affiliates.
apiVersion: apps/v1
kind: Deployment
metadata:
  name: timesten-operator
spec:
  replicas: 1
...
    spec:
      serviceAccountName: timesten-operator
      imagePullSecrets:
      - name: sekret
      containers:
        - name: timesten-operator
          image: container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
...
# An example affinity definition; this pod will only be assigned to a
node
# running on amd64 (the default)
#
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                - key: "kubernetes.io/arch"
                  operator: In
                  values: ["amd64"]
```

b. Save and close the `operator.yaml` file.

7. Install the TimesTen Operator.

```
kubectl create -f operator.yaml
```

The output is the following:

```
deployment.apps/timesten-operator created
```

8. Verify the TimesTen Operator is running.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                 READY   STATUS    RESTARTS   AGE
timesten-operator-577f7fbc6f-tbr7m   1/1     Running   0          61s
```

Congratulations! You installed the TimesTen Operator into a namespace (called `mynamespace`) in your Kubernetes cluster at namespace-scope.

Install in Namespace Two

Let's install the TimesTen Operator in a namespace called `mynamespace2` in your Kubernetes cluster at namespace-scoped.

1. Confirm the namespaces.

   ```
   kubectl get namespaces
   ```

   The output is similar to the following:

   ```
   NAME              STATUS   AGE
   mynamespace       Active   16d
   ...
   mynamespace2      Active   19h
   ```

2. Switch to namespace two (`mynamespace2`, in this example).

   ```
   kubectl config set-context --current --namespace=mynamespace2
   ```

   The output is similar to the following:

   ```
   Context "default" modified.
   ```

3. Change to the directory that contains the YAML manifest files. In this example, the `kube_files/deploy` contains the files.

   ```
   cd kube_files/deploy
   ```

4. Install the required service account, role, and role binding.

   ```
   kubectl create -f service_account.yaml
   ```

   The output is similar to the following:

   ```
   role.rbac.authorization.k8s.io/timesten-operator created
   serviceaccount/timesten-operator created
   rolebinding.rbac.authorization.k8s.io/timesten-operator created
   ```

5. Make a copy of the `service_account_cluster.yaml` file for the second namespace (`service_account_cluster_n2.yaml`, in this example).

   ```
   cp service_account_cluster.yaml service_account_cluster_n2.yaml
   ```

6. Install the `service_account_cluster_n2.yaml` YAML file by doing the following:

   a. (Optional): Display the contents of the `service_account_cluster_n2.yaml` file.

      ```
      cat service_account_cluster_n2.yaml
      ```

The output is similar to the following:

```
# Copyright (c) 2025, Oracle and/or its affiliates.
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
rules:
- apiGroups:
  - ""
  resources:
  - nodes
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - persistentvolumeclaims
  verbs:
  - get
  - list
  - watch
  - delete
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
subjects:
- kind: ServiceAccount
  name: timesten-operator
  #namespace: <NAMESPACE>
roleRef:
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
  apiGroup: rbac.authorization.k8s.io
```

b. Use a text editor to modify the `service_account_cluster_n2.yaml` file.

   Make the following changes:

   - Locate `#namespace`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace2`, in this example).
   - Locate the three occurrences of `#name`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace2`, in this example).

```
vi service_account_cluster_n2.yaml
```

```
# Copyright (c) 2025, Oracle and/or its affiliates.
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace2
rules:
- apiGroups:
  - ""
  resources:
  - nodes
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - persistentvolumeclaims
  verbs:
  - get
  - list
  - watch
  - delete
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace2
subjects:
- kind: ServiceAccount
  name: timesten-operator
  namespace: mynamespace2
roleRef:
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace2
  apiGroup: rbac.authorization.k8s.io
```

c. Save and close the `service_account_cluster_n2.yaml` file.

d. Install the `service_account_cluster_n2.yaml` file.

```
kubectl create -f service_account_cluster_n2.yaml
```

The output is similar to the following:

```
clusterrole.rbac.authorization.k8s.io/timesten-operator created
clusterrolebinding.rbac.authorization.k8s.io/timesten-operator created
```

7. Modify the `operator.yaml` file. In this example, the modifications are the same as the `operator.yaml` file in namespace one. However, these modifications do not need to be the

same as the modifications for namespace one. For example, you can use a different container image:

a. Use a text editor to modify the `operator.yaml` file.

   Replace the following:

   - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` with the name of your image. In this example, the name of the image is `container-registry.oracle.com/timesten/timesten:26.1.1.1.0`.
   - `imagePullSecrets`: Replace `sekret` with the name of your image pull secret. In this example, the name of the image pull secret is `sekret`.
   - If you are running in a multi-architecture environment, modify the `affinity` section, and specify either `amd64` or `arm64`. This example assumes you are running in a multi-architecture environment and sets nodes to `amd64`.

```
vi operator.yaml

# Copyright (c) 2019 - 2025, Oracle and/or its affiliates.
apiVersion: apps/v1
kind: Deployment
metadata:
  name: timesten-operator
spec:
  replicas: 1
...
    spec:
      serviceAccountName: timesten-operator
      imagePullSecrets:
      - name: sekret
      containers:
        - name: timesten-operator
          image: container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
...
# An example affinity definition; this pod will only be assigned to a
node
# running on amd64 (the default)
#
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                - key: "kubernetes.io/arch"
                  operator: In
                  values: ["amd64"]
```

b. Save and close the `operator.yaml` file.

8. Install the TimesTen Operator.

```
kubectl create -f operator.yaml
```

The output is the following:

```
deployment.apps/timesten-operator created
```

9. Verify the TimesTen Operator is running.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                 READY   STATUS    RESTARTS   AGE
   timesten-operator-577f7fbc6f-h8hj8   1/1     Running   0          61s
   ```

Congratulations! You installed the TimesTen Operator into a namespace (called `mynamespace2`) in your Kubernetes cluster at namespace-scope.

Verify Installation

Let's verify there is one TimesTen Operator running in `mynamespace` and a second TimesTen Operator running in `mynamespace2` in a Kubernetes cluster in a namespace-scoped environment. The TimesTen Operator in `mynamespace` services TimesTenClassic objects in `mynamespace` while the TimesTen Operator in `mynamespace2` services TimesTenClassic objects in `mynamespace2`.

1. Review the namespaces.

   ```
   kubectl get namespaces
   ```

   The output is similar to the following:

   ```
   NAME                STATUS   AGE
   mynamespace         Active   16d
   mynamespace2        Active   19h
   ```

2. Confirm there is a TimesTen Operator running in the `mynamespace` namespace.

   ```
   kubectl get pods -n mynamespace
   ```

   The output is similar to the following:

   ```
   NAME                                                         READY
   STATUS     RESTARTS   AGE
   ...
   timesten-operator-577f7fbc6f-tbr7m                           1/1
   Running    0          53m
   ```

3. Confirm there is a TimesTen Operator running in the `mynamespace2` namespace.

   ```
   kubectl get pods -n mynamespace2
   ```

The output is similar to the following:

```
NAME                              READY   STATUS    RESTARTS   AGE
timesten-operator-577f7fbc6f-h8hj8   1/1     Running   0          8m27s
```

Congratulations! You successfully installed the TimesTen Operator in two namespaces in your Kubernetes cluster in a namespace-scoped environment. The TimesTen Operator in the `mynamespace` namespace services TimesTenClassic objects in the `mynamespace` namespace while the TimesTen Operator in the `mynamespace2` namespace services TimesTenClassic objects in the `mynamespace2` namespace.

You are now ready to create TimesTen databases in either namespace. See Create TimesTen Classic Databases.

Install the TimesTen Operator at Cluster-Scope

The examples in this section assume you have obtained the YAML manifest files. See Obtain TimesTen YAML Manifest Files and Helm Charts.

Let's install the TimesTen Operator at cluster-scope. As part of the installation, the `timesten-operator` namespace is created. The TimesTen Operator runs in this namespace in your Kubernetes cluster at cluster-scope. Once installed, this TimesTen Operator services TimesTenClassic objects in all namespaces in your cluster.

1. Change to the directory that contains the YAML manifest files. In this example, the `kube_files/deploy` contains the files.

   ```
   cd kube_files/deploy
   ```

2. Create the necessary privileges to run the TimesTen Operator.

   ```
   kubectl create -f cluster_config.yaml
   ```

   The output is similar to the following

   ```
   namespace/timesten-operator created
   clusterrole.rbac.authorization.k8s.io/timesten-operator created
   serviceaccount/timesten-operator created
   clusterrolebinding.rbac.authorization.k8s.io/timesten-operator created
   ```

   Installing this file results in the creation of the `timesten-operator` namespace.

3. Create a Kubernetes Secret in the `timesten-operator` namespace. This Kubernetes Secret is used as an image pull secret and is required so that the TimesTen Operator can pull a TimesTen container image from an image registry. This example creates the `sekret` Secret.

   ```
   kubectl create secret generic sekret --from-
   file=.dockerconfigjson=$HOME/.docker/config.json --type=kubernetes.io/
   dockerconfigjson -n timesten-operator
   ```

   The output is the following:

   ```
   secret/sekret created
   ```

For more information about creating Kubernetes Secrets, see Pulling Images from Registry during Deployment in the Kubernetes documentation.

4. Modify the `cluster_operator.yaml` file by doing the following:

   a. Use a text editor to modify the `cluster_operator.yaml` file.

      Replace the following:

      - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` with the name of your image. In this example, the name of the image is `container-registry.oracle.com/timesten/timesten:26.1.1.1.0`.
      - `imagePullSecrets`: Replace `sekret` with the name of your image pull secret you created in the prior step. In this example, the name of the image pull secret is `sekret`.
      - If you are running in a multi-architecture environment, modify the `affinity` section, and specify either `amd64` or `arm64`. This example assumes you are running in a multi-architecture environment and sets nodes to `amd64`.

```
vi cluster_operator.yaml

# Copyright (c) 2019 - 2025, Oracle and/or its affiliates.
apiVersion: apps/v1
kind: Deployment
metadata:
  name: timesten-operator
spec:
  replicas: 1
...
    spec:
      serviceAccountName: timesten-operator
      imagePullSecrets:
      - name: sekret
      containers:
        - name: timesten-operator
          image: container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
...
# An example affinity definition; this pod will only be assigned to a
node
# running on amd64 (the default)
#
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                - key: "kubernetes.io/arch"
                  operator: In
                  values: ["amd64"]
```

   b. Save and close the `cluster_operator.yaml` file.

5. Install the TimesTen Operator.

```
kubectl create -f cluster_operator.yaml
```

The output is the following:

```
deployment.apps/timesten-operator created
```

6. Verify the TimesTen Operator is running in the `timesten-operator` namespace .

   ```
   kubectl get pods -n timesten-operator
   ```

   The output is similar to the following:

   ```
   NAME                                 READY   STATUS    RESTARTS   AGE
   timesten-operator-6bf76dd84b-c8j59   1/1     Running   0          51s
   ```

Congratulations! You installed the TimesTen Operator. It is running in the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope. The TimesTen Operator services TimesTenClassic objects in all namespaces in your Kubernetes cluster.

You are now ready to create TimesTen databases in your namespaces. See Create TimesTen Classic Databases.

5

Use Configuration Metadata

This chapter gives an overview of the configuration metadata that is supported in the TimesTen Operator. It also discusses the Kubernetes facilities that you can use to get the configuration metadata into your TimesTen containers. The chapter then discusses additional configuration options. There are examples throughout.

Topics:

Overview of Configuration Metadata and Kubernetes Facilities

Configuration metadata lets you define the attributes of your TimesTen database and how that database is to interact with other applications and components. The TimesTen Operator supports several metadata files that contain the configuration metadata. Each metadata file has a specific name. You use a text editor to create the metadata file with the specific name and then add the appropriate metadata to it. For example, the TimesTen Operator supports the `db.ini` metadata file. You use your editor to create the `db.ini` file and in it you define attributes for you database.

Kubernetes supports various facilities that places the metadata files into the `/ttconfig` directory of the TimesTen containers. See Populate the /ttconfig Directory.

List of Configuration Metadata

Table 5-1 lists the metadata files that are supported by the TimesTen Operator. The table provides a description for each of the metadata files.

Table 5-1 TimesTen Operator Metadata Files

Name	Description
adminUser	Defines an initial user in the database and assigns this user `ADMIN` privileges. Optional.
cachegroups.sql	Defines the cache groups in the database. This file is specific to TimesTen Cache. Required if using TimesTen Cache.
cacheUser	Defines the cache administration user in the database. This file is specific to TimesTen Cache. Required if using TimesTen Cache.

Table 5-1 (Cont.) TimesTen Operator Metadata Files

Name	Description
csWallet	Defines the credentials that are used for Transport Layer Security (TLS) encryption of client/server communications. Required if using TLS.
db.ini	Defines the connection attributes of the database. See List of Connection Attributes in the *Oracle TimesTen In-Memory Database Reference*. Required if using TimesTen Cache. Otherwise, optional.
epilog.sql	Performs operations after the replication scheme is created. Optional.
replicationWallet	Defines the credentials that are used for Transport Layer Security (TLS) encryption of replication traffic between the TimesTen databases. Required if using TLS.
schema.sql	Defines an initial schema for the database. Optional.
sqlnet.ora	Defines how client applications communicate with an Oracle database. This file is specific to TimesTen Cache. Optional.
testUser	Defines a `test` user in the database. This user is used for testing TimesTen using Helm. The user is assigned `CONNECT` privileges. Optional.
tnsnames.ora	Defines the Oracle Database service that TimesTen Cache uses to connect to Oracle Database. Required if using TimesTen Cache.

About Configuration Metadata Details

Metadata files let you specify the attributes and the metadata for your TimesTen database. After you create these files, and you choose a facility to get these files in your TimesTen containers, TimesTen accesses them to determine the attributes and the metadata that is specific to your database.

adminUser

The `adminUser` file creates an initial user with `ADMIN` privileges in the TimesTen database. If you provide this file, this user is created after the database is created. This file must contain one line of the form:

```
user/password
```

cachegroups.sql

The `cachegroups.sql` file contains the create cache group definitions and the cache group operations for your database. You can specify the following cache group definitions and cache operations in this file:

- (Required): `CREATE CACHE GROUP` statements to create TimesTen cache groups

- (Optional): `LOAD CACHE GROUP` statements to load data from the Oracle database into your cache groups
- (Optional): `ttOptUpdateStats` or `ttOptEstimateStats` TimesTen built-in procedures to update statistics on the cache tables

The `cachegroups.sql` file is required if you are using TimesTen Cache in your TimesTenClassic deployment. This requirement ensures cache groups are created before replication is configured. Note: The instance administrator uses the `ttIsql` utility to run the `cachegroups.sql` file.

See:

- CREATE CACHE GROUP and LOAD CACHE GROUP in the *Oracle TimesTen In-Memory Database SQL Reference*
- Cache Group Types in the *Oracle TimesTen In-Memory Database Cache Guide*
- ttOptUpdateStats and ttOptEstimateStats in the *Oracle TimesTen In-Memory Database Reference*

Here is an example of a `cachegroups.sql` file. The file defines two cache groups and loads data into one cache group.

```
CREATE DYNAMIC ASYNCHRONOUS WRITETHROUGH CACHE GROUP writecache
FROM oratt.writetab (
  pk NUMBER NOT NULL PRIMARY KEY,
  attr VARCHAR2(40)
);

CREATE READONLY CACHE GROUP readcache
AUTOREFRESH
  INTERVAL 5 SECONDS
FROM oratt.readtab (
  keyval NUMBER NOT NULL PRIMARY KEY,
  str VARCHAR2(32)
);

LOAD CACHE GROUP readcache COMMIT EVERY 256 ROWS;
```

cacheUser

The `cacheUser` file lets you create the TimesTen cache manager user. This user must have the same name as the cache administration user in the Oracle database, and must already exist in the Oracle database. See Create the Oracle Database Users and Default Tablespace in the *Oracle TimesTen In-Memory Database Cache Guide*.

This file must contain one line of the form,

```
cacheUser/ttPassword/oraPassword
```

where `cacheUser` is the TimesTen cache manager user, `ttPassword` is the TimesTen password for the TimesTen `cacheUser` user, and `oraPassword` is the Oracle database password you specified when you created the `cacheUser` user in the Oracle database.

For example, assume you have created the `cacheuser2` cache administration user in the Oracle Database with password `oraclepwd`. Assume you designate this `cacheuser2` user as the TimesTen cache manager user with a TimesTen password of `ttpwd`. In this example, the `cacheUser` metadata file contains this one line:

```
cacheuser2/ttpwd/oraclepwd
```

The TimesTen Operator creates the `cacheuser2` user with the `ttpwd` in the TimesTen database. This `cacheuser2` user then serves as the cache manager user in your TimesTen database. You do not need to create this TimesTen user. The Operator does it for you.

See Create the TimesTen Users in the *Oracle TimesTen In-Memory Database Cache Guide*.

The Operator grants privileges to the TimesTen `cacheUser` user (`cacheuser2`, in this example) that are appropriate for this user's role as the cache manager. These privileges are:

- `CREATE SESSION`
- `CACHE MANAGER`
- `CREATE ANY TABLE`
- `LOAD ANY CACHE GROUP`
- `REFRESH ANY CACHE GROUP`
- `FLUSH ANY CACHE GROUP`
- `DROP ANY CACHE GROUP`
- `ALTER ANY CACHE GROUP`
- `UNLOAD ANY CACHE GROUP`
- `SELECT ANY TABLE`
- `INSERT ANY TABLE`
- `UPDATE ANY TABLE`
- `DELETE ANY TABLE`

csWallet

In a TimesTen Client/Server environment, data is transmitted between your client applications and your TimesTen database unencrypted by default. However, you can configure TLS for Client/Server to ensure secure network communication between TimesTen clients and servers. To encrypt Client/Server traffic, specify the `/ttconfig/csWallet` file. This file contains the Oracle wallet for the server, which contains the credentials that are used for configuring TLS encryption between your TimesTen database and your Client/Server applications. The file will be available in the containers of your TimesTen databases in the directory `/tt/home/timesten/csWallet`. You can reference this directory in your `db.ini` file (by specifying the `wallet` connection attribute). See Create TLS Certificates for Replication and Client/Server and Create TLS Certificates for Replication and Client/Server.

The client wallet must also be available to your client applications. See Create TLS Certificates for Replication and Client/Server and Configure TLS for Client/Server.

db.ini

The `db.ini` file contains the TimesTen DSN definition for your database.

In TimesTen Classic, the `db.ini` file contains the connection attributes for your database. This file is used to to generate the `sys.odbc.ini` file for the instances. You can specify data store attributes, first connection attributes, and general connection attributes in the `db.ini` file. The name of the DSN is the name of the TimesTenClassic object. For example, if your TimesTenClassic object is called `sample`, the name of your DSN is `sample`.

If you are using TimesTen Cache in your TimesTenClassic deployment, you must specify the `OracleNetServiceName` and the `DatabaseCharacterSet` connection attributes in the `db.ini` file. The `DatabaseCharacterSet` value must match the value of the database character set in the Oracle Database.

Do not specify the the `DataStore` or the `LogDir` connection attributes in the `db.ini` file. The Operator sets these attributes, placing the database files in Kubernetes Persistent Volumes.

See List of Connection Attributes in the *Oracle TimesTen In-Memory Database Reference* for information on the TimesTen connection attributes.

Note

If the `/ttconfig/db.ini` file is not present in a TimesTen container, TimesTen creates a default `sys.odbc.ini` file. For this default `sys.odbc.ini`, the connection attributes are: `Permsize=200` and `DatabaseCharacterSet=AL32UTF8`.

This example shows a sample `db.ini` file that contains various connection attributes for TimesTen databases.

```
PermSize=500
LogFileSize=1024
LogBufMB=1024
DatabaseCharacterSet=AL32UTF8
```

Here is an example that shows a sample `db.ini` file that contains the `OracleNetServiceName` for TimesTen databases that use TimesTen Cache in TimesTen Classic.

```
PermSize=500
LogFileSize=1024
LogBufMB=1024
DatabaseCharacterSet=AL32UTF8
OracleNetServiceName=OraCache
```

epilog.sql

In TimesTen Classic, the `epilog.sql` file includes operations that occur after the replication scheme has been created and the replication agent has been started. For example, if you want to create replicated bookmarks in XLA, you can include the `ttXlaBookmarkCreate` TimesTen built-in procedure in this file.

The Operator instructs the instance administrator to run the `epilog.sql` file using the `ttIsql` utility.

Here is an example of an `epilog.sql` file. The example calls the `ttXlaBookmarkCreate` TimesTen built-in procedure to create XLA bookmarks.

```
call ttXlaBookmarkCreate('mybookmark',0x01);
```

For information about replicated bookmarks, see the ttXlaBookmarkCreate TimesTen built-in procedure in the *Oracle TimesTen In-Memory Database Reference*.

replicationWallet

In TimesTen Classic, TimesTen replication transmits data between your TimesTen databases unencrypted by default. However, you can configure TLS for replication to ensure secure network communication between your replicated TimesTen databases. To do this, specify the /ttconfig/replicationWallet file. This file contains an Oracle wallet, which contains the credentials that are used by TimesTen replication for configuring TLS encryption between your active standby pair of TimesTen databases. See Create TLS Certificates for Replication and Client/Server and Configure TLS for Replication.

If you specify this file, you must include the `replicationCipherSuite` field and optionally include the `replicationSSLMandatory` field in your TimesTenClassic object definition. See the `replicationCipherSuite` entry and the `replicationSSLMandatory` entry in TimesTenClassicSpecSpec and Configure TLS for Replication.

schema.sql

The TimesTen Operator can automatically initialize your database with schema objects, such as users, tables, and sequences. To have the Operator do this, create the `schema.sql` file.

The Operator directs the instance administrator to use the `ttIsql` utility to run the `schema.sql` file immediately after the database is created. This operation occurs before the Operator configures replication or cache in your TimesTen database.

In TimesTen Cache, one or more cache table users own the cache tables. If this cache table user is not the cache manager user, then you must specify the `schema.sql` file and in it you must include the schema user and assign the appropriate privileges to this schema user. For example, if the `oratt` schema user was created in the Oracle database, and this user is not the TimesTen cache manager user, you must create the TimesTen `oratt` user in this file. See Create the Oracle Database Users.

Do not include cache definitions in this file. Instead, use the `cachegroups.sql` metadata file. See cachegroups.sql.

sqlnet.ora

The Oracle Database `sqlnet.ora` file defines the options for how client applications communicate with the Oracle Database. To use TimesTen Cache or to use tools like `ttLoadFromOracle`, define a `sqlnet.ora` file. This file describes how applications, including TimesTen, can connect to your Oracle database. Note: If you define a `sqlnet.ora` file, you must define a `tnsnames.ora` file. See tnsnames.ora.

This is an example of a `sqlnet.ora` file:

```
NAME.DIRECTORY_PATH= {TNSNAMES, EZCONNECT, HOSTNAME}
SQLNET.EXPIRE_TIME = 10
SSL_VERSION = 1.2
```

testUser

The `testUser` file defines a `test` user. This user is used for testing TimesTen with the `helm test` command. The user is granted `CONNECT` privileges. The test connects to a TimesTen database as the `test` user. The test verifies your TimesTen Classic databases are up and running.

The `testUser` file must contain one line of the form:

```
testuser/testuserpassword
```

where `testuser` is the name of your `test` user and `testuserpassword` is the password for this test user.

For more information about using Helm and using the `helm test` command to test TimesTen, see Use Helm in Your TimesTen Kubernetes Operator Environment and Test TimesTen for a Replicated Configuration.

tnsnames.ora

The Oracle Database `tnsnames.ora` file defines Oracle Net Services to which applications connect. You need to use `tnsnames.ora` (and perhaps a `sqlnet.ora` file, described in sqlnet.ora) if you are using:

- TimesTen Cache
- SQL APIs, such as Pro*C, OCI, or ODPI-C
- The `ttLoadFromOracle` feature

For information about the `ttLoadFromOracle` TimesTen built-in procedure, see ttLoadFromOracle in the *Oracle TimesTen In-Memory Database Reference*.

Here is an example of a `tnsnames.ora` file:

```
OraTest =
 (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = database.mynamespace.svc.cluster.local)
     (PORT = 1521))
   (CONNECT_DATA =
     (SERVER = DEDICATED)
     (SERVICE_NAME = OraTest.my.sample.com)))
OraCache =
 (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = database.mynamespace.svc.cluster.local)
     (PORT = 1521))
   (CONNECT_DATA =
     (SERVER = DEDICATED)
     (SERVICE_NAME = OraCache.my.sample.com)))
```

Populate the /ttconfig Directory

You can use different methods to ensure metadata files are placed in the `/ttconfig` directory of TimesTen containers. There is no requirement as to which method to use. Kubernetes provides such facilities as ConfigMaps, Secrets, and init containers for you to consider.

- Using ConfigMaps and Secrets
- Using an init container

Using ConfigMaps and Secrets

You can use one or more ConfigMaps and one or more Secrets to incorporate metadata files into the TimesTen containers. This lets you specify different TimesTen metadata for different deployments. In addition, you can use Secrets for metadata that contains sensitive data, like passwords and certificates.

The use of a ConfigMap to populate the metadata into Pods is a standard Kubernetes technique. One benefit is that you can modify the ConfigMap after it is created, which results in the immediate update of the files that are in the Pod.

> **Note**
>
> TimesTen may not immediately notice and act on the changed content of the files.

When you use ConfigMaps and Secrets to hold your metadata and then reference them in the TimesTenClassic object definition, the TimesTen Operator creates a Projected Volume called `tt-config`. This `tt-config` volume contains the contents of all the ConfigMaps and all the Secrets specified in the `dbConfigMap` and the `dbSecret` fields of your TimesTenClassic object. This volume is mounted as `/ttconfig` in the TimesTen containers.

> **Note**
>
> You can specify one or more ConfigMaps and/or Secrets in your TimesTenClassic object using the `dbConfigMap` and `dbSecret` datum. The result is that these ConfigMaps and/or Secrets are mounted read-only at `/ttconfig`. Since such a mount is read-only, you cannot write into it from an init container. Alternatively, you can use an `emptydir` volume and use an init container to write files into it. However, you cannot combine ConfigMaps and Secrets with an init container. For information about using an init container, see Using an init container.

To use ConfigMaps and Secrets, follow this process:

- Decide what facilities will contain what metadata files. For example, you can use one ConfigMap for all the metadata files. Or, for example, you can use one ConfigMap for the `db.ini` metadata file and one Secret for the `adminUser` and the `schema.sql` metadata files. There is no specific requirement.
- Create the directory (or directories) that will contain the metadata files.
- Use the `kubectl create` command to create the ConfigMap and the Secrets in the Kubernetes cluster.
- Include the ConfigMaps and Secrets in your TimesTenClassic object definition.

The following examples illustrate how to use ConfigMaps and Secrets for a TimesTenClassic object.

- Example Using One ConfigMap
- Example Using One ConfigMap and One Secret

Example Using One ConfigMap

This example uses one ConfigMap (called `sample`) for the `db.ini`, the `adminUser`, and the `schema.sql` metadata files.

1. On your development host, from the directory of your choice, create an empty subdirectory for the metadata files. This example creates the `cm_sample` subdirectory. (The *`cm_sample`* directory is used in the remainder of this example to denote this directory.)

   ```
   mkdir -p cm_sample
   ```

2. Change to the ConfigMap directory.

   ```
   cd cm_sample
   ```

3. Create the `db.ini` file. In this `db.ini` file, define the `PermSize` and `DatabaseCharacterSet` connection attributes.

   ```
   vi db.ini

   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ConnectionCharacterSet=AL32UTF8
   ```

4. Create the `adminUser` file. In this `adminUser` file, create the `sampleuser` user with the `samplepw` password.

   ```
   vi adminUser

   sampleuser/samplepw
   ```

5. Create the `schema.sql` file. In this `schema.sql` file, define the `s` sequence and the `emp` table for the `sampleuser` user. The Operator automatically initializes your database with these object definitions.

   ```
   vi schema.sql

   create sequence sampleuser.s;
   create table sampleuser.emp (
     id number not null primary key,
     name char(32)
   );
   ```

6. Create the ConfigMap. The files in the `cm_sample` directory are included in the ConfigMap. These files are later available in the TimesTen containers.

   In this example:

   - The name of the ConfigMap is `sample`. Replace `sample` with a name of your choosing.
   - This example uses `cm_sample` as the directory where the files that will be copied into the ConfigMap reside. If you use a different directory, replace `cm_sample` with the name of your directory.

   ```
   kubectl create configmap sample --from-file=cm_sample
   ```

   The output is the following:

   ```
   configmap/sample created
   ```

7. Verify the contents of the ConfigMap.

   ```
   kubectl describe configmap sample
   ```

   The output is the following:

   ```
   Name:         sample
   Namespace:    mynamespace
   Labels:       <none>
   Annotations:  <none>

   Data
   ====
   adminUser:
   ```

```
----
sampleuser/samplepw

db.ini:
----
PermSize=200
DatabaseCharacterSet=AL32UTF8
ConnectionCharacterSet=AL32UTF8

schema.sql:
----
create sequence sampleuser.s;
create table sampleuser.emp (
  id number not null primary key,
  name char(32)
);

Events:  <none>
```

8. Include the ConfigMap in the object definition. In the `dbConfigMap` field, specify the name of the your ConfigMap (`sample`, in this example).

   Note this example uses a `storageSize` of `250Gi` (suitable for a production environment). For demonstration purposes, a `storageSize` of `50Gi` is adequate.

   This is an example of using the ConfigMap for a TimesTenClassic object.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: sample
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 250Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    dbConfigMap:
    - sample
```

   The `sample` ConfigMap holds the metadata files. The `tt-config` volume contains the contents of the `sample` ConfigMap.

Example Using One ConfigMap and One Secret

This example uses one ConfigMap (called `myconfig`) for the `db.ini` metadata file and one Secret (called `mysecret`) for the `adminUser` and the `schema.sql` metadata files.

1. On your development host, from the directory of your choice:
   - Create one empty subdirectory for the ConfigMap. This example creates the `cm_myconfig` subdirectory. (The *`cm_myconfig`* directory is used in the remainder of this example to denote this directory.) This directory will contain the `db.ini` metadata file.
   - Create a second empty subdirectory for the Secret. This example creates the `secret_mysecret` subdirectory. (The `secret_mysecret` directory is used in the remainder of this example to denote this directory.) This directory will contain the `adminUser` and the `schema.sql` metadata files.

```
mkdir -p cm_myconfig
mkdir -p secret_mysecret
```

2. Change to the ConfigMap directory.

   ```
   cd cm_myconfig
   ```

3. Create the `db.ini` file in this ConfigMap directory (`cm_myconf`, in this example). In this `db.ini` file, define the `PermSize` and `DatabaseCharacterSet` connection attributes.

   ```
   vi db.ini

   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ConnectionCharacterSet=AL32UTF8
   ```

4. Change to the Secret directory.

   ```
   cd secret_mysecret
   ```

5. Create the `adminUser` file in this Secret directory (`secret_mysecret` in this example). In this `adminUser` file, create the `sampleuser` user with the `samplepw` password.

   ```
   vi adminUser

   sampleuser/samplepw
   ```

6. Create the `schema.sql` file in this Secret directory (`secret_mysecret` in this example). In this `schema.sql` file, define the `s` sequence and the `emp` table for the `sampleuser` user. The Operator automatically initializes your database with these object definitions.

   ```
   vi schema.sql

   create sequence sampleuser.s;
   create table sampleuser.emp (
     id number not null primary key,
     name char(32)
   );
   ```

7. Create the ConfigMap. The files in the `cm_myconfig` directory are included in the ConfigMap and, later, will be available in the TimesTen containers.

   In this example:

   - The name of the ConfigMap is `myconfig`. Replace `myconfig` with a name of your choosing.
   - This example uses `cm_myconfig` as the directory where the files that will be copied into the ConfigMap reside. If you use a different directory, replace `cm_myconfig` with the name of your directory.

   Create the ConfigMap.

   ```
   kubectl create configmap myconfig --from-file=cm_myconfig
   ```

   The output is the following:

   ```
   configmap/myconfig created
   ```

8. Verify the contents of the ConfigMap.

   ```
   kubectl describe configmap myconf
   ```

The output is the following:

```
Name:         myconfig
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>

Data
====
db.ini:
----
PermSize=200
DatabaseCharacterSet=AL32UTF8
ConnectionCharacterSet=AL32UTF8

Events:  <none>
```

9. Create the Secret. The files in the `secret_mysecret` directory are included in the Secret and, later, will be available in the TimesTen containers.

   In this example:

   - The name of the Secret is `mysecret`. Replace `mysecret` with a name of your choosing.
   - This example uses `secret_mysecret` as the directory where the files that will be copied into the Secret reside. If you use a different directory, replace `secret_mysecret` with the name of your directory.

   ```
   kubectl create secret generic mysecret --from-file=secret_mysecret
   ```

   The output is the following:

   ```
   secret/mysecret created
   ```

10. Verify the Secret. Note the contents of the `adminUser` and the `schema.sql` files are not displayed.

    ```
    kubectl describe secret mysecret
    ```

    The output is the following:

    ```

    Name:         mysecret
    Namespace:    mynamespace
    Labels:       <none>
    Annotations:  <none>

    Type:  Opaque

    Data
    ====
    adminUser:   12 bytes
    schema.sql:  98 bytes
    ```

11. Include the ConfigMap and the Secret in the object definition.

    - In the `dbConfigMap` field, specify the name of the your ConfigMap.
    - In the `dbSecret` field, specify the name of the your Secret.

This is an example of using the ConfigMap and the Secret for a TimesTenClassic object.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: sample
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 250Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    dbConfigMap:
    - myconfig
    dbSecret:
    - mysecret
```

The `myconfig` ConfigMap and the `mysecret` Secret holds the metadata files. The `tt-config` volume contains the contents of the `myconfig` ConfigMap and the `mysecret` Secret.

Using an init container

You can use an init container to place your metadata files into the `/ttconfig` directory of the TimesTen containers. An init container lets you to create your own scripts to populate the `/ttconfig` directory. For more information about init containers, see:

https://kubernetes.io/docs/concepts/workloads/pods/init-containers

Note

You can specify one or more ConfigMaps and/or Secrets in your TimesTenClassic object using the `dbConfigMap` and `dbSecret` datum. The result is that these ConfigMaps and/or Secrets are mounted read-only at `/ttconfig`. Since such a mount is read-only, you cannot write into it from an init container. Alternatively, you can use an `emptydir` volume and use an init container to write files into it. However, you cannot combine ConfigMaps and Secrets with an init container. For information about using ConfigMaps and Secrets, see Using ConfigMaps and Secrets.

Here is an example that illustrates how to use an init container for a TimesTenClassic object. The `template` element is required. This element is applied to Pods that contain the TimesTen Classic instances. The example shows you where to specify the script that populates the `/ttconfig` directory. It also uses the `tt-config` volume name in the `volumes` field of the TimesTenClassic object. If you specify a volume with the `tt-config` name, it is automatically mounted at `/ttconfig` in your TimesTen containers.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: init1
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 250Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
  template:
    spec:
```

```
imagePullSecrets:
- name: sekret
initContainers:
- name: initclassic
  image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
  command:
  - sh
  - "-c"
  - |
    /bin/bash <<'EOF'
    Your script to populate /ttconfig goes here
    EOF
  volumeMounts:
  - name: tt-config
    mountPath: /ttconfig
volumes:
- name: tt-config
  emptyDir: {}
```

Additional Configuration Options

This section discusses additional configuration options. These are optional configurations for your environment:

- Persistent Storage
- Additional Resource Specifications

Persistent Storage

When you create a TimesTenClassic object, the Operator automatically creates one or two Persistent Volume Claims (PVCs) per Pod. These PVCs cause Persistent Volumes (PVs) to be allocated by Kubernetes and to be attached to the TimesTen Pods. TimesTen uses the PVs to hold the TimesTen instance and the TimesTen database. If you specify two PVCs, one PV holds the instance and the checkpoint files and the second PV holds the transaction log files.

When you create a TimesTenClassic object, you must specify `storageClassName` and you may specify `storageSize`. These attributes determine the characteristics of the Persistent Volumes. The `storageClassName` must be one that is provided in your Kubernetes environment. For example, in Oracle Kubernetes Environment (OKE), you may use `oci-bv`.

The default storage is `50Gi`. Use the `storageSize` attribute to request a different size. A storage size of `50Gi` may be adequate for demonstration purposes, but in production environments, you should consider greater storage.

TimesTen places the TimesTen installation, the instance, and the database in this storage. It is mounted in each container, in each Pod, as `/tt`. The TimesTen instance is located at `/tt/home/timesten/instances/instance1`.

For TimesTen databases:

- TimesTen best practices recommends that the transaction log files associated with a TimesTen database be located on a different storage volume than the checkpoint files for the database. This provides separate paths to storage for the checkpoint and the transaction log operations. For example, you can store the transaction log files in a high performance storage, while storing the checkpoint files in a slower storage. See Locate Checkpoint and Transaction Log Files on Separate Physical Device in the *Oracle TimesTen In-Memory Database Operations Guide* for more information.

- To locate the checkpoint files and the transaction log files on a separate path of storage, provide a value for a second persistent storage that is used only for the transaction log files. Use the `logStorageSize` attribute for this and control its placement by using the `logStorageClassName` attribute. This causes a second PVC to be created for each Pod, which will then be available in each container at `/ttlog`. (This second storage volume has a `/ttlog` mount point.)

  Here is an example:

  ```
  apiVersion: timesten.oracle.com/v4
  kind: TimesTenClassic
  metadata:
    name: sample
  spec:
    ttspec:
      storageClassName: slower
      storageSize: 750Gi
      logStorageClassName: faster
      logStorageSize: 200G
  ```

Additional Resource Specifications

Kubernetes supports affinity and anti-affinity settings that let applications control their placement within the Kubernetes cluster. These settings can be used to ensure all replicas do not reside on a single physical host.

You can specify affinity settings, node selectors, additional containers, tolerations, resource requirements, and other Kubernetes attributes for the TimesTen Pods and the containers within these Pods that are created by the TimesTen Operator.

In a TimesTenClassic deployment, you specify these resource specifications in the TimesTenClassic object's `.spec.template` datum. The TimesTen Operator passes this `template` to the StatefulSet. For example, when you deploy a TimesTenClassic object, the Operator configures a replicated pair of TimesTen databases that provide high availability. However, since the Operator does not control the placement of Pods, you can achieve an even greater level of high availability by controlling the placement of the TimesTen Pods. TimesTen Pods can then be available in different availability zones or are on different Kubernetes nodes. To do this, you specify the `affinity` option in the `.spec.template` datum for the TimesTenClassic object.

For information about `PodTemplateSpec` see, https://kubernetes.io/docs/reference/kubernetes-api/

Here is an example of specifying the `affinity` setting for a TimesTenClassic object.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: sample
spec:
  …
  template:
    affinity:
      podAntiAffinity:
        preferredDuringSchedulingIgnoredDuringExecution:
          - weight: 1
            podAffinityTerm:
             labelSelector:
              matchExpressions:
               - key: "app"
```

```
            operator: In
            values:
             - ds1
        topologyKey: "kubernetes.io/hostname"
```

About the Default Affinity and Anti-Affinity Settings for TimesTenClassic Objects

Kubernetes affinity and anti-affinity settings constrain how Pods are scheduled on a Node. See Affinity and anti-affinity in the Kubernetes documentation.

By default, the TimesTen Operator adds the following affinity and anti-affinity settings to Pods that are created when deploying a TimesTenClassic object:

- A `nodeAffinity` setting that instructs Kubernetes to provision TimesTen Pods on nodes with the proper architecture (either `amd64` or `arm64`). For more information about these architectures, see About Deploying in a Multi-Architecture Kubernetes Cluster in this book. This architecture setting is required.
- A `podAntiAffinity` section that instructs Kubernetes to schedule Pods for a TimesTenClassic object on different nodes, if possible. This section is preferred. Because the anti-affinity setting is preferred (a lesser constraint), Kubernetes can schedule multiple Pods on the same Node if resource constraints make it necessary. For example, although not recommended, an active standby pair of TimesTen databases can be provisioned in a one Node cluster. However, if two or more Nodes are available, Kubernetes attempts to schedule TimesTen Pods on different Nodes.

If you provide your own `affinity` section in a TimesTenClassic object definition, the TimesTen Operator uses your `affinity` section and does not modify it.

Note

If you specify a `nodeAffinity.requiredDuringSchedulingIgnoredDuringExecution` section, the TimesTen Operator adds the `arch` clause to it.

The following snippet shows the default affinity and anti-affinity settings for a TimesTenClassic object named `sample`.

```
affinity:
  nodeAffinity:
    requiredDuringSchedulingIgnoredDuringExecution:
      nodeSelectorTerms:
      - matchExpressions:
        - key: kubernetes.io/arch
          operator: In
          values:
          - amd64
  podAntiAffinity:
    preferredDuringSchedulingIgnoredDuringExecution:
    - podAffinityTerm:
        labelSelector:
          matchLabels:
            database.timesten.oracle.com: sample
```

```
              topologyKey: kubernetes.io/hostname
            weight: 50
```

About the Default Kubernetes Security Context for TimesTen Pods

A Kubernetes security context defines privilege and access control settings for a Pod or Container. There are several security context settings. See Configure a Security Context for a Pod or Container in the Kubernetes documentation.

The TimesTen Operator adds a default security context, including the Kubernetes default seccomp profile to the Pods it creates. This security context defines the privileges and capabilities in which TimesTen containers run. If you provide your own security context for TimesTen Pods, the TimesTen Operator uses your provided security context and does not make any changes to it.

The following snippet shows the default security context for TimesTen containers.

```
securityContext:
  allowPrivilegeEscalation: false
  capabilities:
    drop:
    - ALL
  privileged: false
  readOnlyRootFilesystem: true
  runAsNonRoot: true
  seccompProfile:
    type: RuntimeDefault
```

About Readiness Probes for TimesTen Containers

A Kubernetes readiness probe enables Kubernetes to determine whether a particular application is *ready*. For example, consider an application that has to perform a lengthy startup procedure. When the application is first started by Kubernetes, it is not immediately ready. It cannot handle requests or workloads until the startup procedure is complete.

The TimesTen Kubernetes Operator (TimesTen Operator) provides different definitions of `ready` for TimesTen (`tt`) containers and defines readiness probes based on these definitions. This applies to replicated and non-replicated configurations. The following sections discuss these readiness probes for replicated and non-replicated configurations:

- About Readiness Probes for Replicated Configurations
- About Readiness Probes for Non-Replicated Configurations

About Readiness Probes for Replicated Configurations

For active/standby pair replication configurations, the TimesTen Operator provides two different definitions of `ready` along with two associated readiness probes. They are as follows:

- A TimesTen database is considered ready if it is the active database in an active/standby pair replication scheme. The TimesTen Operator provides the `/tmp/active` readiness probe for this definition of `ready`.

- A TimesTen database is considered ready if it is loaded and open for connections. The TimesTen Operator provides the `/tmp/readiness` readiness probe for this definition of `ready`.

These two definitions of `ready` fulfill different and incompatible requirements. You must decide what definition of `ready` is best for your environment.

You also have the option of defining your own readiness probe. If you do so, the TimesTen Operator uses your readiness probe rather than one of the provided ones.

To learn about the readiness probes that the TimesTen Operator provides:

- About the /tmp/active Readiness Probe
- About the /tmp/readiness Readiness Probe

About the /tmp/active Readiness Probe

This section discusses the definition of `ready` whereby the `tt` container providing the active database is the one considered `ready`.

The TimesTen Operator creates and manages a file called `/tmp/active` in the `tt` container's file system to determines if the `tt` container is ready. If the `/tmp/active` file exists, the `tt` container is ready. If the file does not exist, the `tt` container is not ready.

The TimesTen Operator provides and defines the `/tmp/active` readiness probe for this definition of `ready`. The TimesTen Operator enables this readiness probe by default for replicated TimesTenClassic objects. The definition is in YAML format and is as follows:

```
readinessProbe:
 exec:
   command:
   - cat
   - /tmp/active
 failureThreshold: 1
 periodSeconds: 10
 successThreshold: 1
```

In this example, Kubernetes runs the `cat` command in the `tt` container every `10` seconds. If the command exits with a return code of `0`, the container is ready. If the command returns any other value, the container is not ready.

Defining a readiness probe in this manner ensures that Kubernetes Services routes incoming client/server connections to databases that are working and that can be read and written. For more information about client/server connections, see About Using Client/Server Drivers.

About the /tmp/readiness Readiness Probe

This section discusses the definition of `ready` whereby a `tt` container providing a TimesTen database that is loaded and open for connections is considered `ready`.

The TimesTen Operator creates and manages a file called `/tmp/readiness` in the `tt` container's file system to determines if the container is ready. If the `/tmp/readiness` file exists, the `tt` container is considered ready. If the file does not exist, the `tt` container is considered not ready.

The TimesTen Operator provides and defines the `/tmp/readiness` readiness probe for this definition of `ready`. The definition is in YAML format and is as follows:

```
readinessProbe:
 exec:
   command:
   - cat
   - /tmp/readiness
 failureThreshold: 1
 periodSeconds: 10
 successThreshold: 1
```

In this example, Kubernetes runs the `cat` command in the `tt` container every `10` seconds. If the command exits with a return code of `0`, the container is ready. If the command returns any other value, the container is not ready.

This readiness probe is useful if you want to replace one or more Nodes in your Kubernetes cluster. In this case, you can cause Kubernetes to `drain` the workload from the Node. This causes Kubernetes to evict any Pods that are running on that Node and create new Pods on other Nodes in the cluster to replace them. Kubernetes supports a *Pod disruption budget* whereby you specify a budget for your application. This budget tells Kubernetes how many evicted Pods in a given Deployment can be tolerated. For example, assume you configure a Deployment with 20 replicas of your application. You could tell Kubernetes to tolerate up to 5 of the replicas being down at a time. When moving a workload from one Node to another, Kubernetes is careful not to delete more than 5 replicas at a time, and waits for their replacements to become ready before deleting more.

In the case of the TimesTen Operator, you can use the `/tmp/readiness` readiness probe to prevent Kubernetes from terminating both the active and standby TimesTen Classic databases simultaneously while draining Kubernetes Nodes.

If you use a Pod disruption budget of `1` on TimesTen, you can drain the workload from one or more Nodes without creating a total TimesTen outage. When Kubernetes deletes a Pod that is running TimesTen in TimesTen Classic, Kubernetes does not know if the Pod contains an active or a standby database. Therefore, it may choose to delete the Pod that contains the active database. This causes a failover to the standby, which disrupts applications if performed during normal hours. There is no way to prevent this. However, Kubernetes does not proceed to delete the other database until the one that was deleted comes back up and is completely in the `Healthy` state.

For more information on the health of a Pod and the `Healthy` state, see About the High Level State of TimesTen Pods.

For information on Kubernetes Pod disruption budgets, see `https://kubernetes.io/docs/concepts/workloads/pods/disruptions/` and `https://kubernetes.io/docs/tasks/run-application/configure-pdb/`.

About Disabling Readiness Probes

We recommend that you do not disable readiness probes. However, if do not want to use a readiness probe for replicated objects, you can instruct the TimesTen Operator not to provision one. Here's how:

In your TimesTenClassic object definition, specify a value of `false` for the `.spec.ttspec.createASReadinessProbe` datum. For example:

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: sample
spec:
  ttspec:
...
    createASReadinessProbe: false
```

For information about the `.spec.ttspec.createASReadinessProbe` datum, see TimesTenClassicSpecSpec.

About Readiness Probes for Non-Replicated Configurations

For non-replicated configurations, the TimesTen Operator provides one definition of `ready` and one associated readiness probe. The definition is as follows: A TimesTen database is considered ready if it is loaded and open for connections. The TimesTen Operator provides the `/tmp/readiness` readiness probe for this definition of `ready`.

The TimesTen Operator creates and manages a file called `/tmp/readiness` in the `tt` container's file system to determines if the container is ready. If the `/tmp/readiness` file exists, the `tt` container is ready. If the file does not exist, the `tt` container is not ready.

By default, the TimesTen Operator provides and defines this `/tmp/readiness` readiness probe for non-replicated TimesTenClassic objects. The definition is in YAML format and is as follows:

```
readinessProbe:
 exec:
   command:
   - cat
   - /tmp/readiness
 failureThreshold: 1
 periodSeconds: 10
 successThreshold: 1
```

In this example, Kubernetes runs the `cat` command in the `tt` container every `10` seconds. If the command exits with a return code of `0`, the container is ready. If the command returns any other value, the container is not ready.

Defining a readiness probe in this manner ensures that Kubernetes Services routes incoming client/server connections to databases that are working and that can be read and written. For more information about client/server connections, see About Using Client/Server Drivers.

You have the option of defining your own readiness probe. If you do so, the TimesTen Operator uses your readiness probe rather than the provided one.

6
Specify CPU and Memory Requests and Limits

This chapter discusses the importance of specifying CPU and memory requests and limits for TimesTen Classic objects. It also provides an understanding of Linux cgroups and gives background information about the Linux `out of memory` (OOM) killer.

Topics:

About Resource Requests and Limits

One of the core Linux technologies that is used to implement containers is cgroups. Cgroups can be used to enforce CPU and memory use limitations on a process or processes.

Kubernetes provides facilities that let you specify the amount of CPU and memory that a container consumes. When specified, Kubernetes uses your requests to do the following:

- Determine the node a particular Pod should be created on: Kubernetes determines which nodes have enough free resources to satisfy your request.
- Enforce these limits at runtime: Kubernetes ensures that applications do not exceed their requests.

Kubernetes chooses which node of the cluster to run a Pod on based on the Pod's resource requests, and the resources available on each node in the cluster. But once a Pod is scheduled onto a node, Kubernetes does not directly enforce limits at runtime. Rather, Kubernetes passes requests to Linux through cgroups. The node's Linux kernel then enforces the limits on Kubernetes behalf.

Let's look at an example of a Pod with the following definition:

```
apiVersion: v1
kind: Pod
metadata:
  name: samplePod
spec:
  containers:
  - image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    name: sample
```

```
        resources:
          limits:
            cpu: 20
            memory: 200Gi
          requests:
            cpu: 20
            memory: 200Gi
```

Kubernetes determines which node it will run the Pod on. It does this by examining the Pod's resources requests to determine which node has enough free resources to accommodate the Pod.

Once the node is determined, Kubernetes creates a `cpu` cgroup for the container (`sample` in this example) and configures the cgroup to have a limit of 20 CPUs. Kubernetes also creates a `memory` cgroup for the container and configures it to have a limit of 200 gigabytes. Kubernetes then forks off the lead process of the newly created container, and associates the initial process with the `cpu` and `memory` cgroups.

Since the lead process is associated with or running under these cgroups, that process and all its children are subject to the limits that the cgroups define. The Linux kernel on the node where the container is running automatically enforces these limits without any involvement from Kubernetes.

CPU limits are easily enforced by Linux. If an application wants to use more CPU than its limit, the kernel can choose not to dispatch the application for a period of time to keep its usage under control.

Memory limit enforcement is different than CPU enforcement. Linux has a component called the `out of memory` (OOM) killer. If processes exceed their intended memory usage, or if the system gets stressed, the OOM killer terminates processes abruptly.

Next, let's consider a Pod with this definition:

```
apiVersion: v1
kind: Pod
metadata:
  name: samplePod
spec:
  containers:
  - image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    name: sample
```

In this Pod, there are no specified memory limits. The container runs in default cgroups with infinite limits. This cgroup is shared by all processes on the node that have no specified memory limit, whether the processes are running in containers or not. In this case, if the Linux node becomes memory constrained, the OOM killer chooses processes from the entire node to terminate. The victim might be TimesTen, it might be the Kubernetes kubelet, it might be some other process, or it might be all of them.

About TimesTen Containerized Deployments

As an in-memory database, TimesTen uses a large amount of memory by design. Processes that run TimesTen may be the largest memory users on a given node. If the operating system gets stressed, TimesTen is likely a prime candidate to get terminated by the Linux OOM killer. Therefore, it is crucial that memory requests and limits be specified for your TimesTen containers. TimesTen also recommends that CPU requests and limits be specified.

> **Note**
>
> Ensure the value of a request and the value of a limit for a resource is the same. For example, if the `memory` request for the `daemonlog` container has a value of `30Mi` ensure the `memory` limit for this `daemonlog` container also has a value of `30Mi`. There are examples later in the chapter that illusrate this.

The `memory` request and `memory` limit for the `tt` container is the most essential and crucial to specify. The value is dependent on the memory required to hold the TimesTen database as well as the memory required for the TimesTen daemon, subdaemons, cache and replication agents, Client/Server server, and so on. The memory required to hold the database is dependent on the size of your database.

The TimesTen Operator provides functionality to accurately size your TimesTen database. This functionality is discussed later. The additional memory required for the TimesTen daemon, subdaemons, Client/Server server is dependent on your SQL and PL/SQL usage and the memory requirements vary with your workload. The TimesTen Operator provides a default of `2Gi` for this additional memory. You can use this default or change it. How to change it is discussed later.

Let’s take a look at the defaults for the TimesTen containers. In all cases, you have the option of changing the default.

- `tt` container:
  - `memory`: This value is discussed in detail throughout this chapter.
  - `cpu`: The value is dependent on how much CPU the `tt` container requires. This includes CPU used by the TimesTen daemon, subdaemons, replication agents, cache agents, and by the Client/Server server. The Client/Server server executes SQL on behalf of your applications, so the value depends on the workload. There is no default.
- `daemonlog` container:
  - `memory`: The default is `200Mi`.
  - `cpu`: The default is `200m`.
- `exporter` container (if provisioned):
  - `memory`: The default is `200Mi`.
  - `cpu`: The default is `200m`.

About Specifying Requests and Limits for TimesTen Containers

The TimesTen Operator provides default values for memory and CPU requests for the `daemonlog` and `exporter` containers. You can override these defaults by specifying specific datum in the `.spec.ttspec` section of your TimesTenClassic object definitions.

These datum are as follows:

- `daemonLogMemoryRequest`
- `daemonLogCPURequest`
- `exporterMemoryRequest`
- `exporterCPURequest`

The TimesTen Operator does not provide a default value for the CPU request of a `tt` container. If you want to specify a value for this CPU request, use the `.spec.ttspec.databaseCPURequest` datum in your TimesTenClassic object definition. See TimesTenClassicSpecSpec.

Let's explore how the TimesTen Operator gathers information for memory and CPU requests and limits and passes the information to Kubernetes. There are two approaches:

- Use specific datum in `.spec.ttspec` for requests and limits: This is the default approach and the approach we recommend. The TimesTen Operator provides specific datum in the `.spec.ttspec` section of your TimesTenClassic object definition and passes the information in these datum to Kubernetes. The TimesTen Operator also automatically determines an appropriate memory request and limit for your `tt` containers.
- Use templates for requests and limits: This approach uses memory and CPU requests and limits information in templates. In this approach, you specify values for memory and CPU requests for the TimesTen containers. The TimesTen Operator passes this information to Kubernetes.

The specific datum are discussed in detail in subsequent sections in this chapter.

Here is a summary list of the datum:

- `automaticMemoryRequests`
- `databaseCPURequest`
- `databaseMemorySize`
- `additionalMemoryRequest`
- `memoryWarningPercent`

For details about these datum, see TimesTenClassicSpecSpec.

Approach 1: Use Specific Datum for Requests and Limits

In this approach, the TimesTen Operator automatically determines the appropriate `memory` request and limit for the `tt` containers. This is the default behavior (`.spec.ttspec.automaticMemoryRequests` is set to `true` by default) for a TimesTenClassic object.

For the remaining TimesTen containers, the TimesTen Operator uses specific datum in the `.spec.ttspec` section of the TimesTenClassic object definition to determine the memory request and limit and the CPU request and limit for each of the TimesTen containers. The TimesTen Operator either uses the default values for the datum or uses a value that you specify. The exception is the CPU request and limit for the `tt` container. Since there is no default, if you want to define a CPU request and limit, you must manually specify a value in the `.spec.ttspec.databaseCPURequest` datum of your TimesTenClassic object. The TimesTen Operator then supplies all this information for memory and CPU requests and limits to Kubernetes.

For details about these datum, including defaults, see TimesTenClassicSpecSpec.

It is essential that the value for the `memory` request for the `tt` container that holds the TimesTen database be accurate.

Recall that the `memory` request for the `tt` container is based on:

- Shared memory for the database: This is dependent on the size of the database.

- Additional memory: This is the memory required in addition to the database. It includes memory that is used for the TimesTen daemon, subdaemons, agents, Client/Server server.

The TimesTen Operator provides the `.spec.ttspec.databaseMemorySize` and `.spec.ttspec.additionalMemoryRequest` datum for these specific memory requirements. The `.spec.ttspec.databaseMemorySize` is used to specify the size of the database and the `.spec.ttspec.additionalMemoryRequest` is used for the additional memory.

The TimesTen Operator adds the value of `.spec.ttspec.additionalMemoryRequest` to the value of `.spec.ttspec.databaseMemorySize`. The sum is the `memory` request and `memory` limit to Kubernetes.

You do not have to specifically specify the `.spec.ttspec.databaseMemorySize` datum for a TimesTenClassic object. If not specified, the TimesTen Operator attempts to determine the appropriate value.

TimesTen provides the `ttShmSize` utility to determine the shared memory requirements of a database, given its `sys.odbc.ini` entry. For information about `ttShmSize`, see ttShmSize in the *Oracle TimesTen In-Memory Database Reference*.

The equivalent for a TimesTen `sys.odbc.ini` file is the TimesTen Operator `db.ini` metadata file. You can provide the `db.ini` file in several ways:

- Embed in a ConfigMap referenced in `.spec.ttspec.dbConfigMap`.
- Embed in a Secret referenced in `.spec.ttspec.dbSecret`.
- Use an init container.

For details about the facilities that you can use to provide metadata files, see Populate the /ttconfig Directory.

TimesTen recommends that you provide the `db.ini` metadata file in either a ConfigMap or a Secret. The TimesTen Operator examines the Configmaps and Secrets, if any, in your TimesTenClassic object. If the `db.ini` is found in a Configmap or Secret, the TimesTen Operator uses the TimesTen `ttShmSize` utility to determine the appropriate amount of shared memory to request based on your database definition. This value is then used for the `.spec.ttspec.databaseMemorySize` value. With this approach, the TimesTen Operator does the database sizing for you.

Let's look at an example:

```
kind: ConfigMap
metadata:
  name: resource9
data:
  adminUser: |
    adminuser/adminuserpwd
  schema.sql: |
    create user sampleuser identified by sampleuserpwd;
    grant admin to sampleuser;
    create table sampleuser.a (b number not null primary key, c number, d 
timestamp);
    insert into sampleuser.a values(-1, -1, sysdate);
  db.ini: |
    Permsize=32768
    TempSize=4096
    LogBufMB=1024
    Connections=2048
    DatabaseCharacterSet=AL32UTF8
```

```
---
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: recommendedoption
spec:
  ttspec:
    dbConfigMap:
    - option1
    storageClassName: standard
    storageSize: 200Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    prometheus:
      insecure: true
```

In this case, the TimesTen Operator runs `ttShmSize` against your provided `db.ini` file and determines the value for `.spec.ttspec.databaseMemorySize` automatically. The TimesTen Operator then adds this value to the value for `.spec.ttspec.additionalMemoryRequest`. The sum is the `memory` request and `memory` limit to Kubernetes.

If you provide the `db.ini` file by using an init container or other mechanism, the TimesTen Operator cannot determine the value for `.spec.ttspec.databaseMemorySize`. By the time the Pod is provisioned and the init container is executed, the Pod has already been created and its memory requirements defined. In such cases, you must manually provide the `.spec.ttspec.databaseMemorySize` as part of your YAML.

TimesTen recommends that you use the `ttShmSize` utility in a TimesTen instance outside of Kubernetes to determine the appropriate value for `.spec.ttspec.databaseMemorySize`. You do not need to create the database.

This example assumes you have created a TimesTen instance outside of Kubernetes and have created a DSN in your `sys.odbc.ini file` with the name `database1`. Use the `ttShmSize` utility based on provided values for the `PermSize`, `TempSize`, `LogBufMB`, and `Connections` connection attributes.

```
ttShmSize -connstr
"DSN=database1;PermSize=32768;TempSize=4096;LogBufMB=1024;Connections=2048"
The required shared memory size is 39991547720 bytes.
```

Specify this value in the `.spec.ttspec.databaseMemorySize` datum.

Let's look at an example that uses an init container and uses the calculated value for `.spec.ttspec.databaseMemorySize`.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: init1
spec:
  ttspec:
    databaseMemorySize: 41Gi
    storageClassName: standard
    storageSize: 200Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    prometheus:
      insecure: true
  template:
    spec:
      initContainers:
      - name: init1a
         command:
        - sh
        - "-c"
        - |
          /bin/bash <<'EOF'
          echo adminuser/adminuserpwd > /ttconfig/adminUser
          echo PermSize=32768 > /ttconfig/db.ini
          echo TempSize=4096 > /ttconfig/db.ini
          echo LogBufMB=1024 > /ttconfig/db.ini
          echo Connections=2048 > /ttconfig/db.ini
          echo DatabaseCharacterSet=AL32UTF8 >> /ttconfig/db.ini
          ls -l /ttconfig
          EOF
        volumeMounts:
        - name: tt-config
          mountPath: /ttconfig
      volumes:
      - name: tt-config
        emptyDir: {}
```

In this case, the TimesTen Operator uses the value you specified for `.spec.ttspec.databaseMemorySize` to determine the size of the shared memory segment to hold the TimesTen database. The TimesTen Operator then adds this value to the value for `.spec.ttspec.additionalMemoryRequest`. The sum is the `memory` request and `memory` limit to Kubernetes.

Approach 2: Use Templates for Requests and Limits

This approach uses a template for specifying resource requests and limits. To enable this behavior, set the `.spec.ttspec.automaticMemoryRequests` datum to `false` for your TimesTenClassic object.

In your YAML for a TimesTenClassic object, you can specify a `template` for Pods. In this `template`, you specify attributes of various containers in the Pods, including the `tt` container. If you specify a `template` for one or more containers, the resource requests and limits for the containers are used by Kubernetes.

TimesTen recommends that you use the `ttShmSize` utility in a TimesTen instance outside of Kubernetes to determine the appropriate value for the `memory` request and limit for the `tt` container. You do not need to create the database.

This example assumes you have created a TimesTen instance outside of Kubernetes and have created a DSN in your `sys.odbc.ini file` with the name `database1`. Use the `ttShmSize` utility based on provided values for the `PermSize`, `TempSize`, `LogBufMB`, and `Connections` connection attributes.

```
ttShmSize -connstr
"DSN=database1;PermSize=32768;TempSize=4096;LogBufMB=1024;Connections=2048"
The required shared memory size is 39991547720 bytes.
```

For information about `ttShmSize`, see ttShmSize in the *Oracle TimesTen In-Memory Database Reference*.

Let's look at an example:

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: resource1
spec:
  ttspec:
    storageClassName: standard
    storageSize: 100Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    prometheus:
      insecure: true
  template:
    spec:
      containers:
      - name: tt
        resources:
          requests:
            memory: "41Gi"
            cpu:    "20"
          limits:
            memory: "41Gi"
            cpu:    "20"
      - name: daemonlog
        resources:
          requests:
            memory: "30Mi"
            cpu:    "210"
          limits:
            memory: "30Mi"
            cpu:    "210"
      - name: exporter
        resources:
          requests:
            memory: "22Mi"
            cpu:    "310m"
          limits:
            memory: "22Mi"
            cpu:    "310m"
```

In this example, `cpu` and `memory` requests and limits for the `tt`, `daemonlog`, and `exporter` containers are included in the template. These resources are specified to Kubernetes.

About Specifying Requests and Limits to Kubernetes

The TimesTen Operator follows a specific order in determining the `cpu` and `memory` request and limits to Kubernetes:

- For the `tt` container that holds your TimesTen database, the TimesTen Operator looks for the following in this order:

  - If you specify a template, the TimesTen Operator uses the values in it.
  - If you specify `.spec.ttspec.databaseMemorySize`, the TimesTen Operator uses its value.
  - If there is a `db.ini` file, the TimesTen Operator uses the values in it.
  - If none of the above are true, the TimesTen Operator uses the default.

  In addition, if you specified a value for `.spec.ttspec.databaseCPURequest`, that value is used as the `cpu` request and `cpu` limit to Kubernetes.

- If you specify resource requests or limits for the `daemonlog` container in your container templates in your TimesTenClassic object, the TimesTen Operator honors those requests. If you do not, the TimesTen Operator uses the values you supply in your object's `.spec.ttspec.daemonLogMemoryRequest` and `.spec.ttspec.daemonLogCPURequest` datum.
- If you specify resource requests or limits for the `exporter` container in your container templates in your TimesTenClassic object, the TimesTen Operator honors those requests. If you do not, the TimesTen Operator uses the values you supply in your object's `.spec.ttspec.exporterMemoryRequest` and `.spec.ttspec.exporterCPURequest` datum.

About Verifying databaseMemorySize

Whether specified by you or determined by the TimesTen Operator, before a database is created, the TimesTen Operator and the TimesTen agent checks that the `tt` containers in the relevant TimesTen Pods have the `memory` resources required to create the database. The TimesTen Operator accomplishes this by running the TimesTen `ttShmSize` utility and comparing it with the memory quotas in the `tt` container's cgroup.

If the required resources are not available, the TimesTen Operator returns an error message (as an Event) and moves the TimesTenClassic object to the `Failed` state.

This checking is performed even if the value of `.spec.ttspec.automaticMemoryRequests` is `false`.

About Runtime Memory Monitoring

The TimesTen Operator monitors the memory usage of TimesTen Pods at runtime. It informs you of the following:

- If any `tt` containers are approaching their specified memory limits.
- If any TimesTen containers have been terminated by the Linux OOM killer.

Kubernetes Events are generated to report on these conditions.

Every `.spec.ttspec.pollingInterval` seconds, the TimesTen agent in each `tt` container queries the container's underlying Linux cgroup to determine the cgroup's `memory.limit_in_bytes` and `memory.usage_in_bytes` and reports these values to the TimesTen Operator. The Kubernetes status of each container is similarly queried. The TimesTen Operator uses this data to generate appropriate Events as needed.

If the `usage` is greater than `.spec.ttspec.memoryWarningPercent` of the `limit`, an Event is generated to notify you. In addition, if the TimesTen Operator observes that one or more of the TimesTen related containers have been terminated or restarted (by the OOM killer or otherwise), the TimesTen Operator reports the observation by using appropriate Events.

7

Create TimesTen Classic Databases

The TimesTen Kubernetes Operator (TimesTen Operator) creates, manages, and monitors TimesTen Classic databases. It supports the following topologies:

- Replicated active standby pair configurations: The TimesTen Operator configures one TimesTen database as the active database, copies the active database to the standby, and configures an active standby pair replication scheme between them.
- Non-replicated configurations: The TimesTen Operator configures one or more TimesTen Classic databases. Each database is independent and has no relationship to each other.

The TimesTen Operator supports TimesTen cache for both replicated and non-replicated configurations. See Work with TimesTen Cache.

Let's learn how to define these configurations and how to deploy and create TimesTen databases in your Kubernetes namespace.

Topics:

About Defining TimesTenClassic Objects

The TimesTenClassic object type provides the metadata and attributes to define and create TimesTen Classic databases in your Kubernetes namespace. The metadata and attributes are applicable to replicated and non-replicated configurations. To distinguish the two configurations, the TimesTenClassic object type provides the `.spec.ttspec.replicationTopology` datum. The value of the `.spec.ttspec.replicationTopology` datum determines whether the TimesTen Operator configures a replicated active standby pair configuration or a non-replicated configuration. Valid values for `.spec.ttspec.replicationTopology` are as follows:

- `activeStandbyPair` (or not specified): The TimesTen Operator configures a replicated active standby pair of TimesTen Classic databases.
- `none`: The TimesTen Operator configures one or more non-replicated TimesTen Classic databases. Each database operates independently and there is no TimesTen replication used.

For non-replicated configurations, with `.spec.ttspec.replicationTopology` set to `none`, the TimesTenClassic object provides additional datum to assist in your customization:

- `replicas`: Determines the number of Pods to be deployed. For example, if you set replicas to `3`, there are three Pods, each containing a TimesTen database.

- `rollingUpdatePartition`: Determines how many databases are upgraded. See Perform Upgrades.

For more information about the TimesTenClassic object type, see Syntax for the TimesTenClassic Object Type.

Let's review two YAML files that contain definitions for replicated and non-replicated TimesTenClassic objects. These are simplistic in nature. There are many more customizations available to you:

- Replicated:

  ```
  apiVersion: timesten.oracle.com/v4
  kind: TimesTenClassic
  metadata:
    name: repsample
  spec:
    ttspec:
      storageClassName: oci-bv
      storageSize: 250Gi
      image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
      imagePullSecret: sekret
      dbConfigMap:
      - repsample
  ```

- Non-replicated:

  ```
  apiVersion: timesten.oracle.com/v4
  kind: TimesTenClassic
  metadata:
    name: norepsample
  spec:
    ttspec:
      storageClassName: oci-bv
      storageSize: 250Gi
      image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
      imagePullSecret: sekret
      replicationTopology: none
      replicas: 3
      dbConfigMap:
      - norepsample
  ```

  The following customizations apply to both configurations:

  - `storageClassName` and `storageSize`: Since TimesTen is a database and is persistent, you have to specify a storage class, which is used to request persistent volumes for the database. The `storageSize` datum determines the amount of storage to be provisioned for TimesTen and its database.
  - `image`: You have to specify the container registry that contains the TimesTen container image. This image runs a specific release of TimesTen.
  - `imagePullSecret`: You have to specify a Kubernetes Secret that authenticates Kubernetes to pull a TimesTen container image from the specified container registry.
  - `dbConfigMap`: Optionally, you can specify one or more ConfigMaps that contain the metadata files for your TimesTen databases. See Use Configuration Metadata.

  The following customizations are specific to the type of configuration:

  - `replicationTopology`: A value of `none` indicates a non-replicated configuration. Since the default `replicationTopology` is `activeStandbyPair`, you do not need to specify `replicationTopology` for replicated configurations.

    `replicas`: This datum is specific to non-replicated configurations.

In addition to the many options for customizing your TimesTenClassic object and your TimesTen configuration, the TimesTen Operator provides metadata files that enable you to customize and define the configuration for your TimesTen databases. These files include `db.ini`, `adminUser`, `cacheUser`, `schema,sql`, `cachegroups.sql`, and others. The TimesTen Operator provides several methods for you to make those files available to the TimesTen Operator and TimesTen. For details, see Use Configuration Metadata.

About the Deployment Process

After you define a TimesTenClassic object for either a replicated or non-replicated configuration, you deploy the object into your namespace using either the `kubectl create` or the `helm install` command. After the object is deployed in your namespace, the TimesTen Operator notices and takes action. The process to create and configure TimesTen and its databases begins:

- StatefulSet: The TimesTen Operator creates a StatefulSet to run TimesTen. The StatefulSet contains a specified number of replicas:
  - For replicated objects, the number of `replicas` is `2`.
  - For non-replicated objects, the TimesTen Opertor uses the value you specified for `.spec.ttspec.replicas`. If you do not specify a value, the TimesTen Operator uses the default value of `1`.
- Pods: Because the TimesTen Operator creates a StatefulSet, Kubernetes in turn provisions `replicas` number of Pods.

  For both replicated and non-replicated configurations, each Pod contains several containers, including `tt`, `daemonlog1`, and `exporter`. If you define additional containers in `.spec.template` of your TimesTenClassic object, they are included in the Pod.
- PersistentVolumes: Kubernetes provisions one or more PersistentVolumes (persistent storage), which are mounted in the TimesTen containers. This is where your TimesTen databases are stored.
- Service: The TimesTen Operator creates a headless Service, which causes Kubernetes to issue unique DNS names for each Pod.

When Kubernetes creates and starts a new Pod as part of a TimesTenClassic object's StatefulSet, the TimesTen Operator interacts with the TimesTen Agent in each Pod to perform the actions to get TimesTen and its databases up and running.

The Operator performs the following actions:

- Creates a TimesTen installation.
- Creates a TimesTen instance that uses the installation just created.
- Creates TimesTen configuration files in the instance based on your provided metadata files (such as `db.ini`).
- Starts the TimesTen instance.
- Creates the TimesTen database.
- Create database users based on your provided metadata files (such as `adminUser` and `cacheUser`).

- Creates database schemas, tables, views, procedures, and other database objects based on your provided metadata files (such as `schema.sql`, `cachegroups.sql`, and `epilog.sql`).

Let's walk through some examples that show you how to define and create replicated and non-replicated TimesTenClassic objects and how the TimesTen Operator uses the information to create TimesTen databases.

About the Examples

The following examples show you how to create YAML manifest files that define replicated and non-replicated configurations. Both examples use the same set of metadata files and both use Kubernetes ConfigMaps to get the metadata files into the `tt` containers. The examples show you how to deploy the TimesTenClassic objects in your Kubernetes namespace. The examples then show you how to monitor the progress of the TimesTen Operator as it creates TimesTen databases and gets them up and running and operational. The examples conclude with showing you how to connect to a TimesTen database and perform operations on it.

The examples use YAML manifest files. If you are using Helm to create TimesTen Classic databases, see Use Helm in Your TimesTen Kubernetes Operator Environment.

For simplicity, let's create the metadata files and ConfigMaps used in the examples. For complete details about metadata files, see Use Configuration Metadata and Populate the /ttconfig Directory.

1. On your development host, from the directory of your choice, create an empty subdirectory for the metadata files and change to that directory. This example creates the `kube_files/cm` subdirectory.

   ```
   mkdir -p kube_files/cm
   cd kube_files/cm
   ```

2. Create a `db.ini` file.

   ```
   vi db.ini

   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ```

3. Create an `AdminUser` file.

   ```
   vi adminUser

   adminuser/adminuserpwd
   ```

4. Create a `schema.sql` file.

   ```
   vi schema.sql

   create table adminuser.emp (id number not null primary key, name char
   (32));
   ```

5. Create the ConfigMaps.
   a. For the replicated object, create the `repsample` ConfigMap.

      ```
      kubectl create configmap repsample --from-file .
      ```

The output is the following:

```
configmap/repsample created
```

b. For the non-replicated object, create the `norepsample` ConfigMap.

```
kubectl create configmap norepsample --from-file .
```

The output is the following:

```
configmap/norepsample created
```

The examples show how to specify the preceding ConfigMaps in the `.spec.ttspec.dbConfigMap` section of your YAML manifest files.

Create Replicated TimesTen Classic Databases

This example shows you how to create and deploy a replicated TimesTenClassic object in your Kubernetes namespace. It shows you how to monitor the TimesTen Operator as it uses the information in the object's definition to create an active standby pair of replicated TimesTen Classic databases.

1. Create the YAML manifest file for the TimesTenClassic object.

```
vi repsample.yaml

apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: repsample
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 10Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    dbConfigMap:
    - repsample
```

Note the following:

- The `storageClassName` is `oci-bv`. Replace `oci-bv` with the name of your storage class.
- The `storageSize` is `10Gi`. Replace `10Gi` with the amount of storage that needs to be requested for each Pod to hold TimesTen.
- The `image` is `container-registry.oracle.com/timesten/timesten:26.1.1.1.0`. Replace `image` with the name and location of your TimesTen container image.
- The `imagePullSecret` is `sekret`. Replace `sekret` with the image pull secret that Kubernetes needs to use to fetch the TimesTen container image.
- The `dbConfigMap` specifies the `repsample` ConfigMap created in About the Examples.

2. Deploy the TimesTenClassic object into your namespace.

   ```
   kubectl create -f repsample.yaml
   ```

   The output is the following:

   ```
   timestenclassic.timesten.oracle.com/repsample created
   ```

3. Monitor deployment.
   a. Check status of object.

      ```
      kubectl get ttc repsample
      ```

      The output is similar to the following:

      ```
      NAME         STATE             ACTIVE    AGE
      repsample    Initializing      None      9s
      ```

      The provisioning starts, but is not completed as indicated by the `Initializing` state.
   b. Wait a few minutes. Then, check status again.

      ```
      kubectl get ttc repsample
      ```

      The output is similar to the following:

      ```
      NAME        STATE    ACTIVE        AGE
      repsample   Normal   repsample-0   2m27s
      ```

      The provisioning process completes. The active and standby databases are up and running and operational. The TimesTen Operator transitions the `repsample` object to the `Normal` state.

4. (Optional): Review the state transitions.

   ```
   kubectl get events
   ```

   The output is similar to the following:

   ```
   LAST SEEN   TYPE      REASON
   OBJECT                                                  MESSAGE
   ...

   4m46s       Normal    Create                  timestenclassic/
   repsample                            Service repsample created
   4m46s       Warning   Warning                 timestenclassic/
   repsample                            Database CPU limit/request not
   specified
   4m46s       Normal    Create                  timestenclassic/
   repsample                            StatefulSet repsample created
   4m46s       Warning   Create                  timestenclassic/
   repsample                            PodMonitor repsample created
   ```

```
3m46s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-0 Agent Up
3m46s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-0 Release 26.1.1.1.0
3m46s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 Agent Up
3m46s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 Release 26.1.1.1.0
3m46s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-0 Daemon Up
3m45s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 Daemon Up
3m30s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-0 Database Loaded
3m30s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-0 Database Updatable
3m29s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-0 RepAgent Running
3m29s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-0 RepScheme Exists
3m29s        Normal    StateChange                timestenclassic/
repsample                              Pod repsample-0 RepState ACTIVE
2m38s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 Database Loaded
2m38s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 RepScheme Exists
2m38s        Normal    StateChange                timestenclassic/
repsample                              Pod repsample-1 RepState IDLE
2m37s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 Database Loaded
2m37s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 RepScheme Exists
2m37s        Normal    StateChange                timestenclassic/
repsample                              Pod repsample-1 RepState IDLE
2m32s        Normal    Info                       timestenclassic/
repsample                              Pod repsample-1 RepAgent Running
2m32s        Normal    StateChange                timestenclassic/
repsample                              Pod repsample-1 RepState STANDBY
2m31s        Normal    StateChange                timestenclassic/
repsample                              TimesTenClassic was Initializing, now
Normal
2m26s        Normal    StateChange                timestenclassic/
repsample                              Pod repsample-0 is Ready
2m26s        Normal    StateChange                timestenclassic/
repsample                              Pod repsample-0 is Active Ready
2m26s        Normal    StateChange                timestenclassic/
repsample                              Pod repsample-1 is Ready
```

During the provisioning process, the TimesTenClassic object transitions from the `Initializing` to the `Normal` state.

5. Verify the existence of the underlying objects.

   1. StatefulSet:

   ```
   kubectl get statefulset repsample
   ```

The output is similar to the following:

```
NAME         READY   AGE
repsample    1/2     7m22s
```

2. Service:

```
kubectl get service repsample
```

The output is similar to the following:

```
NAME         TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)             AGE
repsample    ClusterIP   None         <none>        6625/TCP,8888/TCP   8m2s
```

3. Pods:

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                  READY   STATUS    RESTARTS   AGE
repsample-0                           3/3     Running   0          8m31s
repsample-1                           2/3     Running   0          8m31s
...
```

4. PVCs:

```
kubectl get pvc
```

The output is similar to the following:

```
NAME                            STATUS
VOLUME                                      CAPACITY   ACCESS MODES
STORAGECLASS   AGE
tt-persistent-repsample-0      Bound    csi-f36b2402-9745-46bd-
a023-811839ab518e   250Gi      RWO            oci-bv         8m59s
tt-persistent-repsample-1      Bound    csi-0a0cfd59-b2bf-48b7-
bdef-6ee03794891b   250Gi      RWO            oci-bv         8m59s
```

6. Connect to the active database.
   a. From your development host, establish a shell in the Pod.

      ```
      kubectl exec -it repsample-0 -c tt -- /bin/bash
      ```

   b. Connect to the active database. Insert a row in a table.

      ```
      [timesten@repsample-0 ~]$ ttIsql repsample

      Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights
      reserved.
      Type ? or "help" for help, type "exit" to quit ttIsql.
      ```

```
connect "DSN=repsample";
Connection successful: DSN=repsample;UID=timesten;DataStore=/tt/home/
timesten/datastore/
repsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCII;
AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled=1
;
(Default setting AutoCommit=1)
Command> select * from adminuser.emp;
0 rows found.
Command> describe adminuser.emp;

Table ADMINUSER.EMP:
  Columns:
   *ID                              NUMBER NOT NULL
    NAME                            CHAR (32)
  PRIMARY KEY (ID) RANGE INDEX

1 table found.
(primary key columns are indicated with *)
Command> insert into adminuser.emp values (1,'test');
1 row inserted.
Command> commit;
Command> select * from adminuser.emp;
< 1, test                            >
1 row found.
```

c. Exit from `ttIsql` and from the shell.

```
Command> exit
Disconnecting...
Done.
[timesten@repsample-0 ~]$ exit
exit
```

Congratulations! You successfully created and deployed a replicated TimesTenClassic object. The replicated active standby pair of TimesTen Classic databases are up and running and fully operational.

Create Non-Replicated TimesTen Classic Databases

This example shows you how to create and deploy a non-replicated TimesTenClassic object in your Kubernetes namespace. It shows you how to monitor the TimesTen Operator as it uses the information in the object's definition to create independent TimesTen databases.

1. Create the YAML manifest file for the TimesTenClassic object.

```
vi norepsample.yaml

apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: norepsample
```

```
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 10Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    replicationTopology: none
    replicas: 3
    dbConfigMap:
    - norepsample
```

Note the following:

- The `storageClassName` is `oci-bv`. Replace `oci-bv` with the name of your storage class.
- The `storageSize` is `10Gi`. Replace `10Gi` with the amount of storage that needs to be requested for each Pod to hold TimesTen.
- The `image` is `container-registry.oracle.com/timesten/timesten:26.1.1.1.0`. Replace `image` with the name and location of your TimesTen container image.
- The `imagePullSecret` is `sekret`. Replace `sekret` with the image pull secret that Kubernetes needs to use to fetch the TimesTen container image.
- The `replicationTopology` is `none`. Do not change this setting for non-replicated configurations.
- The `replicas` value is `3`. Replace `3` with the number of TimesTen Pods (each containing a TimesTen database) to provision. The value must be between `1` and `3`. If you omit `replicas`, the default is `1`.
- The `dbConfigMap` specifies the `norepsample` ConfigMap created in About the Examples.

2. Deploy the TimesTenClassic object into your namespace.

   ```
   kubectl create -f norepsample.yaml
   ```

   The output is the following:

   ```
   timestenclassic.timesten.oracle.com/norepsample created
   ```

3. Monitor deployment.

   a. Check status of object.

      ```
      kubectl get ttc norepsample
      ```

      The output is similar to the following:

      ```
      NAME          STATE            ACTIVE   AGE
      norepsample   NoReplicasReady  N/A      43s
      ```

      The provisioning starts, but is not completed as indicated by the `NoReplicasReady` state.

b. Wait a few minutes. Then, check status again.

```
kubectl get ttc norepsample
```

The output is similar to the following:

```
NAME          STATE               ACTIVE   AGE
norepsample   SomeReplicasReady   N/A      74s
```

The provisioning continues. As evidenced by the `SomeReplicasReady` state, some of the databases are ready, but not all.

c. Check the status again.

```
kubectl get ttc norepsample
```

The output is similar to the following:

```
NAME          STATE              ACTIVE   AGE
norepsample   AllReplicasReady   N/A      2m54s
```

The provisioning process completes. Databases are up and running and operational. The TimesTen Operator transitions the `norepsample` object to the `AllReplicasReady` state.

4. (Optional) Review the state transitions.

```
kubectl get events
```

The output is similar to the following:

```
LAST SEEN   TYPE      REASON
OBJECT                                                    MESSAGE
...
6m6s        Normal    Create                         timestenclassic/
norepsample                                    Service norepsample created
6m6s        Warning   Warning                        timestenclassic/
norepsample                                    Database CPU limit/request not
specified
6m6s        Normal    Create                         timestenclassic/
norepsample                                    StatefulSet norepsample created
6m6s        Warning   Create                         timestenclassic/
norepsample                                    PodMonitor norepsample created
6m6s        Normal    StateChange                    timestenclassic/
norepsample                                    TimesTenClassic was Initializing, now
NoReplicasReady
5m10s       Normal    Info                           timestenclassic/
norepsample                                    Pod norepsample-0 Agent Up
5m10s       Normal    Info                           timestenclassic/
norepsample                                    Pod norepsample-0 Release 26.1.1.1.0
5m10s       Normal    Info                           timestenclassic/
norepsample                                    Pod norepsample-0 Instance Exists
5m10s       Normal    Info                           timestenclassic/
```

```
norepsample                                  Pod norepsample-0 Daemon Down
5m9s         Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-0 Daemon Up
5m9s         Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-0 Database None
4m59s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-0 Database Loaded
4m58s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-0 Database Updatable
4m58s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-0 RepAgent Not Running
4m58s        Normal    StateChange                      timestenclassic/
norepsample                                  Pod norepsample-0 is Ready
4m58s        Normal    StateChange                      timestenclassic/
norepsample                                  Pod norepsample-0 state was
Initializing, now Normal
4m58s        Normal    StateChange                      timestenclassic/
norepsample                                  TimesTenClassic was NoReplicasReady,
now SomeReplicasReady
4m48s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Agent Up
4m48s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Release 26.1.1.1.0
4m48s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Instance Exists
4m48s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Daemon Down
4m48s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Daemon Up
4m48s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Database None
3m37s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Database Loaded
3m37s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 Database Updatable
3m37s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-2 RepAgent Not Running
3m37s        Normal    StateChange                      timestenclassic/
norepsample                                  Pod norepsample-2 is Ready
3m37s        Normal    StateChange                      timestenclassic/
norepsample                                  Pod norepsample-2 state was
Initializing, now Normal
3m37s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-1 Agent Up
3m37s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-1 Release 26.1.1.1.0
3m37s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-1 Instance Exists
3m37s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-1 Daemon Down
3m36s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-1 Daemon Up
3m36s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-1 Database None
3m30s        Normal    Info                             timestenclassic/
norepsample                                  Pod norepsample-1 Database Loaded
```

```
3m30s       Normal    Info                   timestenclassic/
norepsample                         Pod norepsample-1 Database Updatable
3m30s       Normal    Info                   timestenclassic/
norepsample                         Pod norepsample-1 RepAgent Not Running
3m30s       Normal    StateChange            timestenclassic/
norepsample                         Pod norepsample-1 is Ready
3m30s       Normal    StateChange            timestenclassic/
norepsample                         Pod norepsample-1 state was
Initializing, now Normal
3m30s       Normal    StateChange            timestenclassic/
norepsample                         TimesTenClassic was SomeReplicasReady,
now AllReplicasReady
```

During the provisioning process, the TimesTenClassic object and TimesTen Pods transition from and to various states.

5. Verify the existence of the underlying objects.

   1. StatefulSet:

```
kubectl get statefulset norepsample
```

   The output is similar to the following:

```
NAME          READY   AGE
norepsample   3/3     8m30s
```

   2. Service:

```
kubectl get service norepsample
```

   The output is similar to the following:

```
NAME          TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)
AGE
norepsample   ClusterIP   None         <none>        6625/TCP,8888/TCP
8m58s
```

   3. Pods:

```
kubectl get pods
```

   The output is similar to the following:

```
NAME                        READY   STATUS    RESTARTS   AGE
norepsample-0               3/3     Running   0          9m15s
norepsample-1               3/3     Running   0          9m15s
norepsample-2               3/3     Running   0          9m15s
...
```

4. PVCs:

```
kubectl get pvc
```

The output is similar to the following:

```
NAME                            STATUS
VOLUME                                       CAPACITY   ACCESS MODES
STORAGECLASS   AGE
tt-persistent-norepsample-0   Bound    csi-00bf2a2e-ef70-4f41-
a3ef-66341f7404ac   250Gi      RWO           oci-bv         9m34s
tt-persistent-norepsample-1   Bound    csi-516d9ef4-9492-4927-
b483-05f7d320cc73   250Gi      RWO           oci-bv         9m34s
tt-persistent-norepsample-2   Bound    csi-99c95d75-
f9d9-4754-9378-0c5a7d288871   250Gi      RWO           oci-bv
9m34s
```

6. Connect to one of the databases.
   a. From your development host, establish a shell in the Pod.

   ```
   kubectl exec -it norepsample-0 -c tt -- /bin/bash
   ```

   b. Connect to the database. Insert a row in a table.

   ```
   ttIsql norepsample

   Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights
   reserved.
   Type ? or "help" for help, type "exit" to quit ttIsql.



   connect "DSN=norepsample";
   Connection successful: DSN=norepsample;UID=timesten;DataStore=/tt/home/
   timesten/datastore/
   norepsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCI
   I;AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled
   =1;
   (Default setting AutoCommit=1)
   Command> select * from adminuser.emp;
   0 rows found.
   Command> describe adminuser.emp;

   Table ADMINUSER.EMP:
     Columns:
      *ID                             NUMBER NOT NULL
       NAME                           CHAR (32)
     PRIMARY KEY (ID) RANGE INDEX

   1 table found.
   (primary key columns are indicated with *)
   Command> insert into adminuser.emp values (1,'test');
   1 row inserted.
   Command> commit;
   Command> select * from adminuser.emp;
   ```

```
< 1, test                              >
1 row found.
```

c. Exit from `ttIsql` and from the shell.

```
Command> exit
Disconnecting...
Done.
[timesten@norepsample-0 ~]$ exit
exit
```

Congratulations! You successfully created and deployed a non-replicated TimesTenClassic object. The non-replicated TimesTen Classic databases are up and running and fully operational.

Modify the Number of Replicas in Non-Replicated Environments

There may be situations where you want to increase or decrease the number of databases in your non-replicated environment. For example, you may want to increase the resources during a peak holiday buying season and then reduce the resources later. You can accomplish this by modifying the number of `replicas` for a TimesTenClassic object.

When you increase the number of replicas, Kubernetes provisions TimesTen in the new Pods.

When you decrease the number of replicas:

- Kubernetes deletes the relevant Pods.
- The TimesTen Operator does not delete the PVCs.

Let's walk through an example. In this example, a TimesTenClassic object is deployed in your namespace. The number of `replicas` is `3`. The example shows you how to decrease the number of replicas to `1` and then increase the number of replicas back to `3`.

1. Confirm there is a TimesTenClassic object deployed in your namespace.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME          STATE              ACTIVE   AGE
   norepsample   AllReplicasReady   N/A      17m
   ```

   The `norepsample` TimesTenClassic object is deployed and is in the `AllReplicasReady` state. All replicas are available and running and the databases are functioning properly.

2. Confirm the number of replicas.

   ```
   kubectl describe ttc norepsample | grep 'Replicas'
   ```

   The output is similar to the following:

   ```
       Replicas:                   3
   ```

   The number of replicas is `3`.

3. Confirm the number of Pods.

   ```
   kubectl get pods
   ```

   The output is similar to the following

   ```
   NAME                                  READY   STATUS    RESTARTS   AGE
   norepsample-0                         3/3     Running   0          18m
   norepsample-1                         3/3     Running   0          18m
   norepsample-2                         3/3     Running   0          18m
   ...
   ```

   There are three Pods running, corresponding to the number of replicas. Each replica contains a TimesTen database.

4. Insert data into databases.
   a. Database running in the `norepsample-0` Pod:

      ```
      kubectl exec -it norepsample-0 -c tt -- /bin/bash
      [timesten@norepsample-0 ~]$ ttIsql norepsample

      Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights
      reserved.
      Type ? or "help" for help, type "exit" to quit ttIsql.



      connect "DSN=norepsample";
      Connection successful: DSN=norepsample;UID=timesten;DataStore=/tt/home/
      timesten/datastore/
      norepsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCI
      I;AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled
      =1;
      (Default setting AutoCommit=1)
      Command> CREATE TABLE testdata (col1 TT_INTEGER);
      Command> INSERT INTO testdata values (0);
      1 row inserted.
      Command> SELECT * FROM testdata;
      < 0 >
      1 row found.
      Command> exit
      Disconnecting...
      Done.
      [timesten@norepsample-0 ~]$ exit
      exit
      ```

      There is one row in the `testdata` table and the value for `col1` is `0`.

   b. Database running in the `norepsample-1` Pod:

      ```
      kubectl exec -it norepsample-1 -c tt -- /bin/bash
      [timesten@norepsample-0 ~]$ ttIsql norepsample

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      reserved.
      ```

```
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=norepsample";
Connection successful: DSN=norepsample;UID=timesten;DataStore=/tt/home/
timesten/datastore/
norepsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCI
I;AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled
=1;
(Default setting AutoCommit=1)
Command> CREATE TABLE testdata (col1 TT_INTEGER);
Command> INSERT INTO testdata values (1);
1 row inserted.
Command> SELECT * FROM testdata;
< 1 >
1 row found.
Command> exit
Disconnecting...
Done.
[timesten@norepsample-1 ~]$ exit
exit
```

There is one row in the `testdata` table and the value for `col1` is `1`.

c. Database running in the `norepsample-2` Pod:

```
kubectl exec -it norepsample-2 -c tt -- /bin/bash
[timesten@norepsample-0 ~]$ ttIsql norepsample

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reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=norepsample";
Connection successful: DSN=norepsample;UID=timesten;DataStore=/tt/home/
timesten/datastore/
norepsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCI
I;AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled
=1;
(Default setting AutoCommit=1)
Command> CREATE TABLE testdata (col1 TT_INTEGER);
Command> INSERT INTO testdata values (2);
1 row inserted.
Command> SELECT * FROM testdata;
< 2 >
1 row found.
Command> exit
Disconnecting...
Done.
[timesten@norepsample-2 ~]$ exit
exit
```

There is one row in the `testdata` table and the value for `col1` is `2`.

5. Decrease the number of replicas.

   a. Edit the `norepsample` TimesTenClassic object, changing `replicas` to `1`.

   ```
   kubectl edit ttc norepsample
   # Please edit the object below. Lines beginning with a '#' will be
   ignored,
   # and an empty file will abort the edit. If an error occurs while
   saving this file will be
   # reopened with the relevant failures.
   #
   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   ...
   spec:
     ttspec:
   ...
       replicas: 1
   ...
   ```

   b. Save your edit.

   The output is similar to the following:

   ```
   timestenclassic.timesten.oracle.com/norepsample edited
   ```

6. Verify the TimesTenClassic object is in the `AllReplicasReady` state.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME          STATE              ACTIVE   AGE
   norepsample   AllReplicasReady   N/A      63m
   ```

7. Confirm the number of Pods.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                  READY   STATUS    RESTARTS    AGE
   norepsample-0                         3/3     Running   0           65m
   ...
   ```

   There is one Pod. One TimesTen database is running in the Pod.

8. Confirm the number of PVCs.

   ```
   kubectl get pvc
   ```

The output is similar to the following:

```
NAME                          STATUS
VOLUME                                    CAPACITY   ACCESS MODES
STORAGECLASS   AGE
tt-persistent-norepsample-0   Bound    csi-836f3962-
cbfa-4f7d-9271-6393167b00bd   50Gi       RWO            oci-bv         67m
tt-persistent-norepsample-1   Bound    csi-b2bfa486-6d09-463f-
a8a3-25a760d1449d   50Gi       RWO            oci-bv         67m
tt-persistent-norepsample-2   Bound    csi-820a206b-1662-4c24-821c-
a947572b618a   50Gi       RWO            oci-bv         67m
```

There are three PVCs. When you modify the number of replicas, the TimesTen Operator does not delete the PVCs associated with a TimesTenClassic object.

9. Increase the number of replicas.
   a. Edit the `norepsample` TimesTenClassic object, changing `replicas` to `3`.

   ```
   kubectl edit ttc norepsample
   # Please edit the object below. Lines beginning with a '#' will be
   ignored,
   # and an empty file will abort the edit. If an error occurs while
   saving this file will be
   # reopened with the relevant failures.
   #
   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   ...
   spec:
     ttspec:
   ...
       replicas: 3
   ...
   ```

   b. Save your edit.

   The output is similar to the following:

   ```
   timestenclassic.timesten.oracle.com/norepsample edited
   ```

10. Verify the TimesTenClassic object is in the `AllReplicasReady` state.

```
kubectl get ttc
```

The output is similar to the following:

```
NAME          STATE              ACTIVE   AGE
norepsample   AllReplicasReady   N/A      76m
```

11. Confirm the number of Pods.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                 READY   STATUS    RESTARTS   AGE
norepsample-0                        3/3     Running   0          77m
norepsample-1                        3/3     Running   0          4m
norepsample-2                        3/3     Running   0          4m
```

There are three Pods. Each Pod is running a TimesTen database.

12. Confirm the number of PVCs.

```
kubectl get pvc
```

The output is similar to the following:

```
NAME                          STATUS
VOLUME                                    CAPACITY   ACCESS MODES
STORAGECLASS   AGE
tt-persistent-norepsample-0   Bound    csi-836f3962-
cbfa-4f7d-9271-6393167b00bd   50Gi       RWO            oci-bv         79m
tt-persistent-norepsample-1   Bound    csi-b2bfa486-6d09-463f-
a8a3-25a760d1449d   50Gi       RWO            oci-bv         79m
tt-persistent-norepsample-2   Bound    csi-820a206b-1662-4c24-821c-
a947572b618a   50Gi       RWO            oci-bv         79m
```

There are three PVCs associated with the three TimesTen databases.

13. Verify the data in the databases.

    a. Database running in the `norepsample-0` Pod:

    ```
    kubectl exec -it norepsample-0 -c tt -- /bin/bash
    [timesten@norepsample-0 ~]$ ttIsql norepsample

    Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights
    reserved.
    Type ? or "help" for help, type "exit" to quit ttIsql.



    connect "DSN=norepsample";
    Connection successful: DSN=norepsample;UID=timesten;DataStore=/tt/home/
    timesten/datastore/
    norepsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCI
    I;AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled
    =1;
    (Default setting AutoCommit=1)
    Command> tables;
      TIMESTEN.TESTDATA
    1 table found.
    Command> SELECT * FROM testdata;
    < 0 >
    1 row found.
    ```

Since this Pod was not deleted when you decreased the number of replicas, the data in the database has not changed.

b. Database running in the `norepsample-1` Pod:

```
kubectl exec -it norepsample-1 -c tt -- /bin/bash
[timesten@norepsample-1 ~]$ ttIsql norepsample

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reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=norepsample";
Connection successful: DSN=norepsample;UID=timesten;DataStore=/tt/home/
timesten/datastore/
norepsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCI
I;AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled
=1;
(Default setting AutoCommit=1)
Command> tables;
0 tables found.
Command> exit
Disconnecting...
Done.
[timesten@norepsample-1 ~]$ exit
exit
```

The TimesTen Operator correctly provisions TimesTen in the `norepsample-1` Pod and has correctly overwritten the original database.

c. Database running in the `norepsample-2` Pod:

```
kubectl exec -it norepsample-2 -c tt -- /bin/bash
[timesten@norepsample-2 ~]$ ttIsql norepsample

Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights
reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=norepsample";
Connection successful: DSN=norepsample;UID=timesten;DataStore=/tt/home/
timesten/datastore/
norepsample;DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=US7ASCI
I;AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled
=1;
(Default setting AutoCommit=1)
Command> tables;
0 tables found.
Command> exit
Disconnecting...
Done.
```

```
[timesten@norepsample-2 ~]$ exit
exit
```

The TimesTen Operator correctly provisions TimesTen in the `norepsample-2` Pod and has correctly overwritten the original database.

Congratulations! You successfully modified the number of replicas for a TimesTenClassic object in a non-replicated environment.

8

Use Helm in Your TimesTen Kubernetes Operator Environment

You can use Helm and TimesTen Helm charts to install and upgrade TimesTen CRDs and the TimesTen Operator. You can also use Helm to create and upgrade TimesTen databases.

Topics:

Overview of Helm and TimesTen Helm Charts

This section provides an overview of Helm, discusses Helm charts, and details the Helm charts for TimesTen. It covers the following topics:

About Helm

Helm is the package manager for Kubernetes. It is an open source project by the Cloud Native Computing Foundation (CNCF).

Kubernetes provides a rich interface for deploying applications through an extensible object model. Typically, you write manifest YAML files describing objects and then use the `kubectl` command to feed the YAML files to Kubernetes. Kubernetes then configures the Kubernetes cluster to match. Built-in object types include Pods, Services, and Persistent Volumes. The TimesTen Operator extends the Kubernetes object type system by adding objects of type TimesTenClassic.

Helm is an optional layer on top of this architecture. Rather than manually creating YAML files and using `kubectl` to apply the files, Helm gives application developers the ability to package a set of YAML files into a single entity called a chart. Such a chart can be installed into a Kubernetes cluster using a single command.

The YAML files provided in a chart are templates. When installing a chart, you can specify a set of values to replace into the chart. Helm processes the YAML in the chart, substituting values provided by you, and submits the final version to Kubernetes through the `kubectl` command.

Helm also provides advanced facilities to manage applications:

- Charts can depend on other charts. Helm can assist in maintaining the dependency relationships. Helm can install an application and its dependencies as a unit.
- You can list charts that have been installed in your Kubernetes cluster and refer to them by name.
- You can use the `helm test` command to verify the functioning of the application.
- You can upgrade an installed application by applying a new version of the chart that installed the application.
- You can delete charts by name.

For more information about Helm, see https://helm.sh/docs/.

About a Helm Chart

A Helm chart is a collection of files in a directory. A chart consists of at minimum the following:

- `Chart.yaml`: This file contains metadata about the chart, including its name and version.
- `templates`: This is a directory containing one or more YAML file templates. A sophisticated templating language allows variables to be substituted into these files. Ultimately, when the chart is installed, Helm substitutes values into these templates and presents the result to Kubernetes with the `kubectl` command.
- `values.yaml`: This file contains default values for the variables, which are used in the chart's templates.

About Helm Charts for TimesTen

TimesTen provides TimesTen Helm charts in its container images. You have several options for obtaining container images and downloading the Helm charts from these container images. The examples assume that you have downloaded the charts into the `kube_files/helm` directory. See Prepare to Use the TimesTen Kubernetes Operator.

The following charts are included in the TimesTen container images's `helm` directory:

- `ttcrd`: Install the TimesTen Custom Resource Definitions (CRDs) into the Kubernetes cluster.
- `ttoperator`: Installs the TimesTen Operator in a namespace at namespace-scope.
- `ttclusteroperator`: Installs the TimesTen Operator at cluster-scope.
- `ttclassic`: Creates TimesTen databases.

Each chart requires a different level of authority. As a result, the charts are packaged as separate charts so they can be installed with appropriate privileges. In addition, a single TimesTen Operator can simultaneously create and manage multiple TimesTen databases. Because the relationship between TimesTen Operators and TimesTen databases is not one to one, there are different charts for installing the TimesTen Operator and for creating TimesTen databases.

About Installing and Testing a Release

You use Helm to install the `ttcrd`, `ttoperator`, `ttclusteroperator` and `ttclassic` Helm charts.

After installation, you can test the installation of the TimesTen Operator and the creation of TimesTen databases by running the `helm test` command. This command creates a `test` Pod that runs a command specific to the chart being tested. If the command finishes with exit code `0`, the test succeeds and the `test` Pod is deleted. Any other error code indicates failure. In the case of failure, the `test` Pod is not deleted.

The examples in later sections show you how to install the charts and how to use the `helm test` command.

About Versions in a Chart.yaml File

Each chart contains metadata in its `Chart.yaml` file.

As an example, let's look at the `Chart.yaml` file for the `ttoperator` chart. In particular, let's look at the `appVersion` and `version` metadata.

```
apiVersion: v2
name: ttoperator
description: A Helm chart for Kubernetes

# A chart can be either an 'application' or a 'library' chart.
#
# Application charts are a collection of templates that can be packaged into
versioned archives
# to be deployed.
#
# Library charts provide useful utilities or functions for the chart
developer. They're included as
# a dependency of application charts to inject those utilities and functions
into the rendering
# pipeline. Library charts do not define any templates and therefore cannot
be deployed.
type: application

# This is the chart version. This version number should be incremented each
time you make changes
# to the chart and its templates, including the app version.
# Versions are expected to follow Semantic Versioning (https://semver.org/)
version: 261110.1.0

# This is the version number of the application being deployed. This version
number should be
# incremented each time you make changes to the application. Versions are not
expected to
# follow Semantic Versioning. They should reflect the version the application
is using.
```

```
# It is recommended to use it with quotes.
appVersion: "26.1.1.1.0"
```

The value of `version` reflects the TimesTen release number without dots (`.`) followed by `.1.0`. For example, for release `26.1.1.1.0`, the value of `version` is `261110.1.0`.

Similarly, the value of `appVersion` reflects the TimesTen release number, but is in a different format. For example, for release `26.1.1.1.0`, the value of `appversion` is `26.1.1.1.0`.

About the Helm Substitution Engine and Language

Helm has a robust substitution engine and language that lets you specify your own values for variables in a chart's `template` YAML manifest files. For more information about chart templates, see https://helm.sh/docs/chart_template_guide/getting_started/.

For each chart, the TimesTen Operator provides variables specific to that chart. For example, the `ttoperator` chart has variables and default values specific to the TimesTen Operator deployment. Similarly, the `ttclassic` chart has variables and default values specific to the deployment of TimesTen Classic databases. You can change the default values for the provided variables.

You can define variables and values for those variables either on the `helm` command line or by providing a YAML file with the values. The values may be strings, lists, arbitrary YAML, or entire files.

For information about the variables for the TimesTen-specific Helm charts, see Helm Charts for the TimesTen Kubernetes Operator.

Install the TimesTenClassic CRD

Let's walk-through an example showing you how to install the TimesTenClassic CRD using a Helm chart. For information about the TimesTenClassic CRD, see About the TimesTenClassic CRD

Before you begin, ensure you complete the tasks in Prepare to Use the TimesTen Kubernetes Operator. After completing the tasks, the Helm charts reside in a location on your development host. In this example, the location is `kube_files/helm`.

Note

Since CRDs are cluster-wide, after you install the TimesTenClassic CRD, it is available to all namespaces in the cluster.

To install the TimesTenClassic CRD using Helm, you use the `ttcrd` Helm chart. In this example. the location of the `ttcrd` chart is in the `kube_files/helm` directory on your development host.

Note

Do not modify this chart.

1. On your development host, change to the `helm` directory.

   ```
   cd kube_files/helm
   ```

2. Install the `ttcrd` chart.

   ```
   helm install ttcrd ./ttcrd
   ```

   The output is similar to the following.

   ```
   NAME: ttcrd
   LAST DEPLOYED: Wed Jun 25 19:29:32 2025
   NAMESPACE: mynamespace
   STATUS: deployed
   REVISION: 1
   TEST SUITE: None
   NOTES:
   Version 261110.1.0 the ttcrd chart has been installed.

   This release is named "ttcrd".

   To learn more about the release, try:

     $ helm status ttcrd
     $ helm get all ttcrd
     $ helm history ttcrd

   To rollback to a previous version of the chart, run:

     $ helm rollback ttcrd <REVISION>
       - run 'helm history ttcrd' for a list of revisions.
   ```

3. Confirm the TimesTenClassic CRD is defined in your Kubernetes cluster.

   ```
   kubectl get crd | grep timesten
   ```

   The output is similar to the following:

   ```
   timestenclassics.timesten.oracle.com
   2025-06-25T19:29:33Z
   ```

Congratulations! You successfully installed the TimesTenClassic CRD.

Install the TimesTen Operator

TimesTen provides the `ttoperator` chart in TimesTen container images. You use this chart to install the TimesTen Operator in your namespace. The chart contains a default configuration for installing the TimesTen Operator Deployment. The Deployment causes Kubernetes to create one or more Pods, each of which runs the TimesTen Operator.

For information about obtaining TimesTen Helm charts from TimesTen container images, see Obtain TimesTen YAML Manifest Files and Helm Charts.

The TimesTen Operator requires a TimesTen container image. You need to specify the TimesTen container image, container registry, and image pull secret that you are using for the TimesTen Operator. The `ttoperator` chart provides default settings as well as variables that enable you to change the defaults. For information about these variables, see The ttoperator Chart.

> **Note**
>
> The service account, roles, and role bindings that the TimesTen Operator requires to run properly are automatically installed when you install the `ttoperator` chart.

After you decide the variables you want to customize, you have two options:

- Create a YAML file that defines the variables that you want to use to configure your environment. Next, to install the chart, pass this YAML file to the `helm install` command by specifying the `-f` option.
- Specify the variables on the command line by running the `helm install` command with the `--set` option.

For more information about these options, see https://helm.sh/docs/intro/using_helm/.

The example creates a YAML file. Let's review how to make customizations for the container image, container registry, and image pull secret using a YAML file:

```
image:
  repository: container-registry.oracle.com/timesten/timesten
  tag: "26.1.1.1.0"
imagePullSecrets:
  - name: sekret
```

For the `image` variable, specify the following:

- `repository`: The name of your container image. This example uses `container-registry.oracle.com/timesten/timesten`.
- `tag`: The name of the image tag. This example uses `"26.1.1.1.0"`, corresponding to TimesTen release `26.1.1.1.0`.

Let's install the TimesTen Operator. Let's assume you have previously created a `kube_files/helm/customyaml` directory for your customized YAML file.

> **Note**
>
> The installation process creates and deploys the service account, role, and rolebinding objects required to run the TimesTen Operator in your namespace.

1. On your development host, change to the `helm` directory.

   ```
   cd kube_files/helm
   ```

2. Create a YAML file that defines the variables for your configuration.

   ```
   vi customyaml/tt_operator.yaml

   image:
     repository: container-registry.oracle.com/timesten/timesten
     tag: "26.1.1.1.0"
   imagePullSecrets:
     - name: sekret
   ```

3. Install the TimesTen Operator by installing the `ttoperator` chart.

   ```
   helm install -f customyaml/tt_operator.yaml ttoper ./ttoperator
   ```

   Let's look at this `helm install` command:

   - The `-f` option is used to pass the customized YAML file to the `helm install` command.
   - The name of the file that contains the customizations is `tt_operator.yaml`, which is located in the `customyaml` directory.
   - The name of the release is `ttoper`.
   - The name of the chart that installs the TimesTen Operator is `ttoperator`.

   Let's look at the output from the `helm install` command.

   ```
   NAME: ttoper
   LAST DEPLOYED: Thu Jan  16 02:54:39 2025
   NAMESPACE: default
   STATUS: deployed
   REVISION: 1
   NOTES:
   Version 261110.1.0 of the ttoperator chart has been installed.

   This release is named "ttoper".

   To learn more about the release, try:

     $ helm status ttoper
     $ helm get all ttoper
     $ helm history ttoper

   To rollback to a previous version of the chart, run:

     $ helm rollback ttoper <REVISION>
       - run 'helm history ttoper' for a list of revisions.

   To test the operator, run:

     $ helm test ttoper
   ```

   Note the following:

   - The `ttoperator` chart version is `261110.1.0` corresponding to TimesTen release `26.1.1.1.0`.
   - The release name is `ttoper`.

- The status of the release is `deployed`.

4. (Optional) Verify the release.

   ```
   helm list
   ```

   Output.

   ```
   NAME    NAMESPACE       REVISION
   UPDATED                                STATUS    CHART
   APP VERSION
   ttoper  default         1               2025-01-16 02:54:39.916210368
   +0000 UTC deployed ttoperator-261110.1.0  26.1.1.1.0
   ```

   The `helm list` command shows the `ttoper` release exists and is installed in your namespace.

5. Confirm the TimesTen Operator is running in your namespace.

   ```
   kubectl get pods
   ```

   The output is the following:

   ```
   NAME                               READY   STATUS    RESTARTS   AGE
   timesten-operator-55c6f99-zqlct    1/1     Running   0          10m
   ```

Congratulations! You successfully installed the `ttoperator` chart. The TimesTen Operator is running in your namespace.

Test the TimesTen Operator

To test the TimesTen Operator, the test Pod uses the `curl` command to access the TimesTen Operator's readiness probe endpoint. If the TimesTen Operator self-reports that it is ready, the test succeeds.

If you previously disabled exposing probes from the TimesTen Operator by setting `probes.expose=0` in your customized YAML file, `helm test` does not work. We recommend you do not disable exposing probes.

To test the TimesTen Operator, you test the `ttoperator` chart release running in your namespace.

1. Examine the `ttoperator` chart release.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME    NAMESPACE       REVISION
   UPDATED                                STATUS    CHART
   APP VERSION
   ttoper  default         1               2025-01-16 02:54:39.916210368
   +0000 UTC deployed ttoperator-261110.1.0  26.1.1.1.0
   ```

The `ttoper` release of the `ttoperator` chart is installed in your namespace.

2. Test the release.

```
helm test ttoper
```

The output is the following:

```
NAME: ttoper
LAST DEPLOYED: Thu Jan  16 02:54:39 2025
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE:     ttoper-ttoperator-test
Last Started:   Thu Jan  16 02:55:17 2025
Last Completed: Thu Jan  16 02:55:20 2025
Phase:          Succeeded
NOTES:
Version 261110.1.0 of the ttoperator chart has been installed.

This release is named "ttoper".

To learn more about the release, try:

  $ helm status ttoper
  $ helm get all ttoper
  $ helm history ttoper

To rollback to a previous version of the chart, run:

  $ helm rollback ttoper <REVISION>
    - run 'helm history ttoper' for a list of revisions.

To test the operator, run:

  $ helm test ttoper
```

The test for the `ttoper` release succeeded.

Congratulations! You successfully tested the TimesTen Operator. The test succeeded, indicating the TimesTen Operator is running in your namespace and operating properly.

Create TimesTen Databases and Test TimesTen

This section shows you how to create replicated and non-replicated TimesTen databases. It covers the following topics:

- About Creating TimesTen Databases
- About Using the ttclassic Helm Chart
- Create Replicated TimesTen Databases
- Test TimesTen for a Replicated Configuration
- Create Non-Replicated TimesTen Databases
- Test TimesTen for a Non-Replicated Configuration

About Creating TimesTen Databases

The TimesTen Operator creates, manages, and monitors TimesTen Classic databases. It supports the following topologies:

- Replicated active standby pair configurations: The TimesTen Operator configures one TimesTen database as the active database, copies the active database to the standby, and configures an active standby pair replication scheme between them.
- Non-replicated configurations: The TimesTen Operator configures one or more TimesTen Classic databases. Each database is independent and has no relationship to each other.

You use the `ttclassic` Helm chart to create TimesTen Classic databases for both replicated and non-replicated configurations. To distinguish the two configurations, the `ttclassic` chart provides the `replicationTopology` variable. Let's look at an example and then discuss the specifics.

Here are two YAML files that define the variables for both configurations. How you use these files to create TimesTen databases is discussed in a later section.

- Replicated:

  ```
  storageClassName: oci-bv
  storageSize: 10Gi
  image:
    repository: container-registry.oracle.com/timesten/timesten
    tag: "26.1.1.1.0"
  imagePullSecret: sekret
  replicationTopology: activeStandbyPair
  dbConfigMap:
    - name: repsamplehelm
    directory: cm
  ```

  The `replicationTopology` variable has a value of `activeStandbyPair`, indicating a replicated configuration in which the TimesTen Operator creates an active standby pair of TimesTen databases. Since the default value for the `replicationTopology` variable is `activeStandbyPair`, you have the option of not specifying the `replicationTopology` variable for replicated configurations.

- Non-replicated:

  ```
  storageClassName: oci-bv
  storageSize: 10Gi
  image:
    repository: container-registry.oracle.com/timesten/timesten
    tag: "26.1.1.1.0"
  imagePullSecret: sekret
  replicationTopology: none
  replicas: 3
  rollingUpdatePartition: 2
  dbConfigMap:
    - name: norepsamplehelm
    directory: cm
  ```

  The `replicationTopology` variable has a value of `none`, indicating a non-replicated configuration in which the TimesTen Operator creates one or more non-replicated

TimesTen databases, each of which operates independently without replication configured. In addition, the `ttclassic` chart provides additional variables to assist in your customizations:

- `replicas`: Determines the number of Pods to be configured. Each Pod contains a TimesTen database. For example, if `replicas` is `3`, there are three Pods each containing a TimesTen database. The default is `1`.
- `rollingUpdatePartition`: Determines how many databases are upgraded. The upgrade procedure is discussed in a later section.

The following customizations apply to both configurations:

- `storageClassName` and `storageSize`: Since TimesTen is a database and is persistent, you have to specify a storage class, which is used to request persistent volumes for the database. The `storageSize` datum determines the amount of storage to be provisioned for TimesTen and its database.
- `image`: For `repository`, you must specify the container registry that contains the TimesTen container image. For `tag`, you specify an image tag. Taken together, `image` in this example represents the container registry that contains the TimesTen container image along with the image tag representing the release of TimesTen.
- `imagePullSecret`: You have to specify a Kubernetes Secret that authenticates Kubernetes to pull a TimesTen container image from the specified container registry.
- `dbConfigMap`: Optionally, you can specify one or more ConfigMaps that contain the metadata files for your TimesTen databases. You do not create these ConfigMaps. Rather, the `ttclassic` chart installation process creates the ConfigMaps for you. How this is done is discussed later in this chapter.

There are many more customizations available to you. See The ttclassic Chart. In addition, the TimesTen Operator provides metadata files that enable you to customize and define the configuration for your TimesTen databases. These files include `testUser`, `db.ini`, `adminUser`, `cacheUser`, `schema,sql`, `cachegroups.sql`, and others. The TimesTen Operator provides several methods for you to make those files available to the TimesTen Operator and TimesTen. For details, see Use Configuration Metadata.

About Using the ttclassic Helm Chart

The `ttclassic` Helm chart contains the information needed to deploy replicated and non-replicated TimesTen database in your Kubernetes namespace. There are many customizations available to meet your preferred configuration. There are variables specific to the `ttclassic` chart for such customizations. The About Creating TimesTen Databases section discusses some of these customizations. For additional customizations, see The ttclassic Chart.

The TimesTen Operator provides metadata files to further customize your database. One file of particular interest is `testUser`. After TimesTen is deployed, you can use the `helm test` command to test TimesTen. The test operation requires that a TimesTen `test` user exist in the TimesTen database. This user connects to the database as part of the testing process. This user must be defined before installing the `ttclassic` chart. The TimesTen Operator provides the `testUser` metadata file for this purpose. The file contains one line of the form:

```
testuser/testuserpassword
```

where `testuser` is the name of the TimesTen user to use for testing TimesTen and `testuserpassword` is the password for this `test` user. For details, see Use Configuration Metadata.

If you are using Kubernetes ConfigMaps or Secrets as the facilities to place metadata files into the TimesTen containers, you do not need to create them. Instead, when you install the `ttclassic` chart, the ConfigMaps and Secrets are automatically created as part of the installation process. To facilitate the process, you must create a directory within the `ttclassic` chart directory tree and create the metadata files in this directory. There are examples later in this section that show you how to do this.

After you decide your configurations needs and review the variables you are using for these customizations, you have the following options for supplying these variables as part of the `ttclassic` chart's installation process:

- Create a YAML file for the variables. When installing the `ttclassic` chart, pass this YAML file to the `helm install` command by specifying the `-f` option.
- Specify the variables on the command line by running the `helm install` command with the `--set` option.

The examples use a YAML file. For specifics about these options including the syntax, see https://helm.sh/docs/intro/using_helm/ in the Helm documentation.

The examples show you how to use the `ttclassic` Helm chart to define and deploy replicated and non-replicated TimesTen databases. Both examples use the same set of metadata files and both use Kubernetes ConfigMaps to get the metadata files into the `tt` containers.

For simplicity, let's create the metadata files and ConfigMaps used in the examples. For complete details about metadata files, see Use Configuration Metadata and Populate the /ttconfig Directory.

1. On your development host, change to the `ttclassic` directory. In this example, the directory location is `kube_files/helm/ttclassic`.

   ```
   cd kube_files/helm/ttclassic
   ```

2. Create a directory for the metadata files.

   ```
   mkdir cm
   ```

3. Create metadata files in the directory used for the metadata files (`cm` in this example). These metadata files are used in the examples throughout the chapter.
   a. Create the `testUser` file.

      ```
      vi cm/testUser
      ```

      ```
      sampletestuser/sampletestuserpwd1
      ```

   b. Create the `db.ini` file.

      ```
      vi cm/db.ini
      ```

      ```
      PermSize=200
      DatabaseCharacterSet=AL32UTF8
      ```

   c. Create the `adminUser` file.

      ```
      vi cm/adminUser
      ```

      ```
      adminuser/adminuserpwd
      ```

d. Create the `schema.sql` file.

   ```
   vi cm/schema.sql

   create table adminuser.emp (id number not null primary key, name char
   (32));
   ```

You created the metadata files and the directory for them. Save the location of the directory. You need it later.

Create Replicated TimesTen Databases

This example shows you how to create replicated TimesTen Classic databases using the `ttclassic` Helm chart. The example uses a YAML manifest file and assumes you have created the `kube_files/helm/customyaml` directory for the file.

1. On your development host, change to the `helm` directory.

   ```
   cd kube_files/helm
   ```

2. Create a YAML file that defines the variables for your replicated configuration.

   ```
   vi customyaml/repsamplehelm.yaml

   storageClassName: oci-bv
   storageSize: 10Gi
   image:
     repository: container-registry.oracle.com/timesten/timesten
     tag: "26.1.1.1.0"
   imagePullSecret: sekret
   replicationTopology: activeStandbyPair
   dbConfigMap:
     - name: repsamplehelm
       directory: cm
   ```

   Note the following:

   - The `storageClassName` is `oci-bv`. Replace `oci-bv` with the name of your storage class.
   - The `storageSize` is `10Gi`. Replace `10Gi` with the amount of storage that needs to be requested for each Pod to hold TimesTen.
   - For the `image` variable:
     – `repository`: The `repository` is `container-registry.oracle.com/timesten/timesten`. Replace `container-registry.oracle.com/timesten/timesten` with the name and location of your TimesTen container image.
     – `tag`: The tag is `26.1.1.1.0`. Replace `tag` with the tag for the TimesTen release.
   - The `imagePullSecret` is `sekret`. Replace `sekret` with the image pull secret that Kubernetes needs to use to fetch the TimesTen container image.
   - The `replicationTopology` is `activeStandbyPair`, indicating a replicated configuration consisting of an active standby pair of TimesTen databases.
   - The name of the ConfigMap is `repsamplehelm`. The location of the metadata files is in the `cm` directory, which is located within the `kube_file/helm/ttclassic` directory tree..

3. Install the `ttclassic` chart.

   ```
   helm install -f customyaml/repsamplehelm.yaml repsamplehelm ./ttclassic
   ```

   Let's look at this `helm install` command:

   - The `-f` option indicates that a YAML file is passed to the `helm install` command.
   - The name of the YAML file that contains the customizations is `repsamplehelm.yaml`, which is located in the `customyaml` directory.
   - The name of the release is `repsamplehelm`.
   - The name of the chart is `ttclassic`, which is located in the `kube_files/helm/ttclassic` directory.

   Let's look at the output from the `helm install` command.

   ```
   NAME: repsamplehelm
   LAST DEPLOYED: Thu Jan  16 14:58:40 2025
   NAMESPACE: default
   STATUS: deployed
   REVISION: 1
   NOTES:
   Version 261110.1.0 of the ttclassic chart has been installed.

   This release is named "repsamplehelm".

   To learn more about the release, try:

     $ helm status repsamplehelm
     $ helm get all repsamplehelm
     $ helm history repsamplehelm

   To rollback to a previous version of the chart, run:

     $ helm rollback repsamplehelm <REVISION>
       - run 'helm history repsamplehelm' for a list of revisions.
   ```

   Note the following:

   - The `ttclassic` chart version is `261110.1.0`, corresponding to TimesTen release `26.1.1.1.0`.
   - The release name is `repsamplehelm`.
   - The status of the release is `deployed`.

4. (Optional) Verify the release.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   repsamplehelm   default         1               2025-01-16
   ```

```
14:58:40.109402333 +0000 UTC deployed        ttclassic-261110.1.0
26.1.1.1.0
...
```

The `helm list` command shows the `repsamplehelm` release exists and is installed in your namespace.

5. Monitor the progress.

   ```
   kubectl get ttc repsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME            STATE           ACTIVE   AGE
   repsamplehelm   Initializing    None     44s
   ```

   The provisioning starts, but is not yet complete as indicated by the `Initializing` state.

   Wait a few minutes. Then, check again.

   ```
   kubectl get ttc repsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME            STATE    ACTIVE            AGE
   repsamplehelm   Normal   repsamplehelm-0   4m23s
   ```

   The provisioning process completes. The active standby pair of TimesTen databases are up and running and operational as indicated by the `Normal` state.

6. Confirm the ConfigMap and the metadata files exist.

   ```
   kubectl get configmap repsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME            DATA   AGE
   repsamplehelm   4      8m50s
   ```

   Check the metadata files.

   ```
   kubectl describe configmap repsamplehelm
   ```

   The output is similar to the following:

   ```
   Name:         repsamplehelm
   Namespace:    default
   Labels:       app.kubernetes.io/managed-by=Helm
   Annotations:  meta.helm.sh/release-name: repsamplehelm
                 meta.helm.sh/release-namespace: default

   Data
   ```

```
====
adminUser:
----
adminuser/adminuserpwd

db.ini:
----
PermSize=200
DatabaseCharacterSet=AL32UTF8

schema.sql:
----
create table adminuser.emp (id number not null primary key, name char
(32));

testUser:
----
sampletestuser/sampletestuserpwd1


BinaryData
====

Events:  <none>
```

The `repsamplehelm` ConfigMap exists and contains the metadata files. Since the `testUser` file exists, you can use Helm to test TimesTen. See [Test TimesTen for a Replicated Configuration](#).

7. (Optional) Confirm the Pods.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                 READY    STATUS     RESTARTS    AGE
repsamplehelm-0                      3/3      Running    0           11m
repsamplehelm-1                      2/3      Running    0           11m
...
```

The `repsamplehelm-0` and `repsamplehelm-1` Pods are running in your namespace. Each Pod is running TimesTen.

Congratulations! You successfully installed the `ttclassic` chart for a replicated configuration. An active standby pair of TimesTen Classic databases are up and running and fully operational.

Test TimesTen for a Replicated Configuration

To test TimesTen, a `test` Pod is created. It runs a script that attempts to connect to a TimesTen database by using TimesTen's client/server access. If the script can connect to the database, the script then looks at internal metadata to verify that the database is functioning properly. If the test succeeds, the `test` Pod is deleted.

The test connects to the database as the `test` user. You define this `test` user in the `testUser` metadata file. This user has `CONNECT` privileges, but does not have any other privileges. This limits the test and the `test` user's access to the database. If you do not define a `test` user, the test fails.

The test verifies that the active standby pair of TimesTen Classic databases are up and running and that replication between them is configured.

Let's test TimesTen.

1. Confirm the `ttclassic` release.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   repsamplehelm   default         1               2025-01-16
   14:58:40.109402333 +0000 UTC deployed        ttclassic-261110.1.0
   26.1.1.1.0
   ```

   The `repsamplehelm` release exists in your namespace.

2. Test TimesTen.

   ```
   helm test repsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME: repsamplehelm
   LAST DEPLOYED: Thu Jan  16 14:58:40 2025
   NAMESPACE: default
   STATUS: deployed
   REVISION: 1
   TEST SUITE:     repsamplehelm-ttclassic-test
   Last Started:   Thu Jan  16 15:21:45 2025
   Last Completed: Thu Jan  16 15:21:49 2025
   Phase:          Succeeded
   NOTES:
   Version 261110.1.0 of the ttclassic chart has been installed.

   This release is named "repsamplehelm".

   To learn more about the release, try:

     $ helm status repsamplehelm
     $ helm get all repsamplehelm
     $ helm history repsamplehelm

   To rollback to a previous version of the chart, run:

     $ helm rollback repsamplehelm <REVISION>
       - run 'helm history repsamplehelm' for a list of revisions.
   ```

The test for the `repsamplehelm` release succeeded.

Congratulations! You successfully tested TimesTen. The active and standby databases are up and running and replication between them is configured.

Create Non-Replicated TimesTen Databases

This example shows you how to create non-replicated TimesTen Classic databases using the `ttclassic` Helm chart. The example uses a YAML manifest file and assumes you have created the `kube_files/helm/customyaml` directory for the file.

1. On your development host, change to the `helm` directory.

   ```
   cd kube_files/helm
   ```

2. Create a YAML file that defines the variables for your non-replicated configuration.

   ```
   vi customyaml/norepsamplehelm.yaml

   storageClassName: oci-bv
   storageSize: 10Gi
   image:
     repository: container-registry.oracle.com/timesten/timesten
     tag: "26.1.1.1.0"
   imagePullSecret: sekret
   replicationTopology: none
   replicas: 3
   rollingUpdatePartition: 2
   dbConfigMap:
     - name: norepsamplehelm
       directory: cm
   ```

   Note the following:

   - The `storageClassName` is `oci-bv`. Replace `oci-bv` with the name of your storage class.
   - The `storageSize` is `10Gi`. Replace `10Gi` with the amount of storage that needs to be requested for each Pod to hold TimesTen.
   - For the `image` variable:
     - `repository`: The `repository` is `container-registry.oracle.com/timesten/timesten`. Replace `container-registry.oracle.com/timesten/timesten` with the name and location of your TimesTen container image.
     - `tag`: The tag is `26.1.1.1.0`. Replace `tag` with the tag for the TimesTen release.
   - The `imagePullSecret` is `sekret`. Replace `sekret` with the image pull secret that Kubernetes needs to use to fetch the TimesTen container image.
   - For a non-replicated configuration:
     - The `replicationTopology` is `none`, indicating a non-replicated configuration consisting of `replicas` number of Pods. Each Pod contains an independent TimesTen database.
     - The number of `replicas` is `3`, indicating the number of Pods, each of which contains a TimesTen database. Replace `3` with the number of Pods you want provisioned. Valid values are between `1` and `3`, with `1` being the default.

  - The rollingUpdatePartition is 2. This variable is specific to upgrades and determines the number of TimesTen databases to upgrade. Kubernetes upgrades Pods with an ordinal value that is greater than or equal to the rollingUpdatePartition value. For example, if you have three non-replicated Pods (replicas = 3 and Pods are norepsamplehelm-0, norepsamplehelm-1, and norepsamplehelm-2) and you set rollingUpdatePartition to 2, the norepsamplehelm-2 Pods is upgraded, but the norepsamplehelm-1 and norepsamplehelm-0 Pods are not. There are examples in the upgrade section that show you how rollingUpdatePartition works. You have the option of changing the value during the upgrade process.
- The name of the ConfigMap is norepsamplehelm. The location of the metadata files is in the cm directory, which is located within the kube_file/helm/ttclassic directory tree..

3. Install the ttclassic chart.

```
helm install -f customyaml/norepsamplehelm.yaml norepsamplehelm ./ttclassic
```

Let's look at this helm install command:

- The -f option indicates that a YAML file is passed to the helm install command.
- The name of the YAML file that contains the customizations is norepsamplehelm.yaml, which is located in the customyaml directory.
- The name of the release is norepsamplehelm.
- The name of the chart is ttclassic, which is located in the kube_files/helm/ttclassic directory.

Let's look at the output from the helm install command.

```
NAME: norepsamplehelm
LAST DEPLOYED: Thu Jan  16 17:42:47 2025
NAMESPACE: default
STATUS: deployed
REVISION: 1
NOTES:
Version 261110.1.0 of the ttclassic chart has been installed.

This release is named "norepsamplehelm".

To learn more about the release, try:

  $ helm status norepsamplehelm
  $ helm get all norepsamplehelm
  $ helm history norepsamplehelm

To rollback to a previous version of the chart, run:

  $ helm rollback norepsamplehelm <REVISION>
    - run 'helm history norepsamplehelm' for a list of revisions.
```

Note the following:

- The ttclassic chart version is 261110.1.0, corresponding to TimesTen release 26.1.1.1.0.

- The release name is `norepsamplehelm`.
- The status of the release is `deployed`.

4. (Optional) Verify the release.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   norepsamplehelm default         1               2025-01-16
   17:42:47.180635098 +0000 UTC deployed        ttclassic-261110.1.0
   22.1.1.26.0
   ```

   The `helm list` command shows the `norepsamplehelm` release exists and is installed in your namespace.

5. Monitor the progress.

   ```
   NAME              STATE             ACTIVE   AGE
   norepsamplehelm   NoReplicasReady   N/A      94s
   ```

   The provisioning starts, but is not yet complete as indicated by the `NoReplicasReady` state.

   Wait a few minutes. Then, check again.

   ```
   kubectl get ttc norepsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME              STATE              ACTIVE   AGE
   norepsamplehelm   AllReplicasReady   N/A      12m
   ```

   The provisioning process completes. Databases are up and running and operational as indicated by the `AllReplicasReady` state.

6. Confirm the ConfigMap and the metadata files exist.

   ```
   kubectl get configmap norepsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME              DATA   AGE
   norepsamplehelm   4      15m
   ```

   Check the metadata files.

   ```
   kubectl describe configmap norepsamplehelm
   ```

The output is similar to the following:

```
Name:         norepsamplehelm
Namespace:    default
Labels:       app.kubernetes.io/managed-by=Helm
Annotations:  meta.helm.sh/release-name: norepsamplehelm
              meta.helm.sh/release-namespace: default

Data
====
testUser:
----
sampletestuser/sampletestuserpwd1

adminUser:
----
adminuser/adminuserpwd

db.ini:
----
PermSize=200
DatabaseCharacterSet=AL32UTF8

schema.sql:
----
create table adminuser.emp (id number not null primary key, name char
(32));


BinaryData
====

Events:  <none>
```

The `norepsamplehelm` ConfigMap exists and contains the metadata files. Since the `testUser` file exists, you can use Helm to test TimesTen. See Test TimesTen for a Non-Replicated Configuration.

7. (Optional) Confirm the Pods.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                               READY   STATUS    RESTARTS   AGE
norepsamplehelm-0                  3/3     Running   0          17m
norepsamplehelm-1                  3/3     Running   0          17m
norepsamplehelm-2                  3/3     Running   0          17m
...
```

There are three Pod running in your namespace, each of which contains an independent TimesTen database.

Congratulations! You successfully installed the `ttclassic` chart for a non-replicated configuration. TimesTen databases are up and running and fully operational.

Test TimesTen for a Non-Replicated Configuration

To test TimesTen, a `test` Pod is created. It runs a script that attempts to connect to all of the TimesTen databases (the replicas) by using TimesTen's client/server access. If the script can connect to the database, the script then looks at internal metadata to verify that the database is functioning properly. If the test succeeds, the `test` Pod is deleted.

The test connects to the database as the `test` user. You define this `test` user in the `testUser` metadata file. This user has `CONNECT` privileges, but does not have any other privileges. This limits the test and the `test` user's access to the database. If you do not define a `test` user, the test fails.

The test verifies TimesTen databases are up and running and fully operational.

Let's test TimesTen.

1. Confirm the `ttclassic` release.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   norepsamplehelm default         1               2025-01-16
   17:42:47.180635098 +0000 UTC deployed        ttclassic-261110.1.0
   22.1.1.26.0
   ```

   The `norepsamplehelm` release exists in your namespace.

2. Test TimesTen.

   ```
   helm test norepsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME: norepsamplehelm
   LAST DEPLOYED: Thu Jan  16 17:42:47 2025
   NAMESPACE: default
   STATUS: deployed
   REVISION: 1
   TEST SUITE:     norepsamplehelm-ttclassic-test
   Last Started:   Thu Jan  16 18:17:22 2025
   Last Completed: Thu Jan  16 18:17:26 2025
   Phase:          Succeeded
   NOTES:
   Version 261110.1.0 of the ttclassic chart has been installed.

   This release is named "norepsamplehelm".

   To learn more about the release, try:
   ```

```
  $ helm status norepsamplehelm
  $ helm get all norepsamplehelm
  $ helm history norepsamplehelm

To rollback to a previous version of the chart, run:

  $ helm rollback norepsamplehelm <REVISION>
    - run 'helm history norepsamplehelm' for a list of revisions.
```

The test for the `norepsamplehelm` release succeeded.

Congratulations! You successfully tested TimesTen. TimesTen databases are up and running and fully operational.

Upgrade

This section shows you how to upgrade the TimesTen CRDs, the TimesTen Operator, and both replicated and non-replicated TimesTenClassic objects and associated TimesTen databases. It covers the following topics:

- About Upgrading
- Upgrade the TimesTen CRDs
- Upgrade the TimesTen Operator
- Upgrade Replicated TimesTen Databases
- Upgrade Non-Replicated TimesTen Databases

About Upgrading

You can use Helm to upgrade TimesTen CRDs and the TimesTen Operator. You can also use Helm to perform an automated upgrade of both replicated and non-replicated TimesTen Classic databases.

TimesTen provides several options for obtaining container images that contain the release of TimesTen that you want to use for the upgrade. These container images contain the Helm charts for the upgrade. For information about obtaining container images and downloading Helm charts from a container image, see Prepare to Use the TimesTen Kubernetes Operator.

The upgrade examples make the following assumptions:

- Container image: The container image that contains the new release of TimesTen is `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.
- Download directory: The directory on your development host that contain the Helm charts for the upgrade is `new_kube_files/helm`.

Upgrade the TimesTen CRDs

To upgrade the TimesTen CRDs in your cluster, use the `ttcrd` chart from the new release.

Note the following:

- You cannot downgrade TimesTen CRDs.
- Since CRDs are cluster-scoped, if you delete TimesTen CRDs from your Kubernetes cluster, all TimesTenClassic objects that are deployed in this cluster are also deleted.

1. Confirm the current `ttcrd` release.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME    NAMESPACE       REVISION
   UPDATED                                STATUS   CHART
   APP VERSION
   ttcrd   default         1               2025-01-16 20:50:47.406557985
   +0000 UTC deployed ttcrd-261110.1.0       26.1.1.1.0
   ```

   The `ttcrd` chart `version` is `261110.1.0` and `appversion` is `26.1.1.1.0` corresponding to TimesTen release `26.1.1.1.0`.

2. On your development host, change to the `new_kube_files/helm` directory.

   ```
   cd new_kube_files/helm
   ```

3. Upgrade to the new release.

   ```
   helm upgrade ttcrd ./ttcrd
   ```

   The output is similar to the following:

   ```
   Release "ttcrd" has been upgraded. Happy Helming!
   NAME: ttcrd
   LAST DEPLOYED: Thu Jan  16 19:07:52 2025
   NAMESPACE: default
   STATUS: deployed
   REVISION: 2
   TEST SUITE: None
   NOTES:
   Version 261120.1.0 the ttcrd chart has been installed.

   This release is named "ttcrd".

   To learn more about the release, try:

     $ helm status ttcrd
     $ helm get all ttcrd
     $ helm history ttcrd

   To rollback to a previous version of the chart, run:

     $ helm rollback ttcrd <REVISION>
       - run 'helm history ttcrd' for a list of revisions.
   ```

   The TimesTen CRDs are upgraded to the new release.

Congratulations! You successfully upgraded the TimesTen CRDs.

Upgrade the TimesTen Operator

You can upgrade the TimesTen Operator while there are TimesTenClassic objects running in your namespace. To upgrade the TimesTen Operator in your namespace, use the new release of the `ttoperator` chart.

The upgrade process requires you to complete the following steps:

- Create a new YAML file. In this file, you specify the container image that contains the new release of TimesTen.
- Use the `helm get values` command for the upgrade. The example shows you how to do this.

The example assumes you have created a `new_kube_files/helm/customyaml` directory.

1. On your development host, change to the `helm` directory that contains the new Helm charts.

   ```
   cd new_kube_files/helm
   ```

2. Create a YAML file and in it specify the name of the TimesTen image you want to use for the upgrade.

   ```
   vi customyaml/upgradeoperator.yaml

   image:
     repository: container-registry.oracle.com/timesten/timesten
     tag: "26.1.1.2.0"
   ```

3. Before the upgrade, do the following:

   a. Verify that the TimesTen Operator is running.

      ```
      kubectl get pods
      ```

      The output is the following:

      ```
      NAME                              READY   STATUS    RESTARTS   AGE
      norepsamplehelm-0                 3/3     Running   0          6h19m
      norepsamplehelm-1                 3/3     Running   0          6h19m
      norepsamplehelm-2                 3/3     Running   0          6h19m
      repsamplehelm-0                   3/3     Running   0          9h
      repsamplehelm-1                   2/3     Running   0          9h
      timesten-operator-55c6f99-zqlct   1/1     Running   0          2d21h
      ```

   b. Confirm the image that the TimesTen Operator is running.

      ```
      kubectl describe deployment timesten-operator | grep Image
      ```

      The output is the following:

      ```
      Image:      container-registry.oracle.com/timesten/timesten:26.1.1.1.0
      ```

c. Confirm the state of the TimesTenClassic objects.

```
kubectl get ttc
```

The output is similar to the following:

```
NAME               STATE              ACTIVE             AGE
norepsamplehelm    AllReplicasReady   N/A                6h28m
repsamplehelm      Normal             repsamplehelm-0    9h
```

The TimesTenClassic objects and associated databases are functioning properly.

4. Confirm the Helm chart release.

```
helm list
```

The output is similar to the following:

```
NAME            NAMESPACE       REVISION
UPDATED                                 STATUS
CHART                   APP VERSION
...
ttoper          default         1               2025-01-16
02:54:39.916210368 +0000 UTC deployed        ttoperator-261110.1.0
26.1.1.1.0
```

5. Upgrade the TimesTen Operator to the new release. To upgrade the TimesTen Operator, use the `ttoperator` chart from the new release and use the customized YAML file that references the new image.

> **Note**
>
> We recommend this syntax. This ensures existing customizations are preserved.

```
helm get values ttoper --all > prev-values-ttop.yaml
```

```
helm upgrade -f prev-values-ttop.yaml -f customyaml/upgradeoperator.yaml
ttoper ./ttoperator
```

Let's look at this `helm upgrade` command:

- The `get values ttoper` Helm command retrieves the values for the current release, including existing customizations. The result of this command is piped into the `prev-values-ttop.yaml` file. You can choose any name for this file.
- The `helm upgrade` command uses the `prev-values-ttop.yaml` file with the customized `upgradeoperator.yaml` file to do the upgrade. Specifically, the values in the `prev-values-ttop.yaml` file are used except when overridden by the values in the customized `upgradeoperator.yaml` file. The `upgradeoperator.yaml` file takes

precedence over the `prev-values-ttop.yaml` file since it was listed last on the command line.

Let's look at the output from the `helm upgrade` command.

```
Release "ttoper" has been upgraded. Happy Helming!
NAME: ttoper
LAST DEPLOYED: Thu Jan  16 00:20:34 2025
NAMESPACE: default
STATUS: deployed
REVISION: 2
NOTES:
Version 261120.1.0 of the ttoperator chart has been installed.

This release is named "ttoper".

To learn more about the release, try:

  $ helm status ttoper
  $ helm get all ttoper
  $ helm history ttoper

To rollback to a previous version of the chart, run:

  $ helm rollback ttoper <REVISION>
    - run 'helm history ttoper' for a list of revisions.

To test the operator, run:
```

Note the following:

- The `ttoper` release is upgraded. The release revision is 2.
- The status of the release is `deployed`.
- The `ttoperator` chart `version` is `261120.1.0` corresponding to TimesTen release `26.1.1.2.0`.

6. Test the TimesTen Operator is running.

```
helm test ttoper
```

The output is similar to the following:

```
NAME: ttoper
LAST DEPLOYED: Thu Jan  16 00:20:34 2025
NAMESPACE: default
STATUS: deployed
REVISION: 2
TEST SUITE:     ttoper-ttoperator-test
Last Started:   Thu Jan  16 00:20:54 2025
Last Completed: Thu Jan  16 00:20:57 2025
Phase:          Succeeded
NOTES:
Version 261120.1.0 of the ttoperator chart has been installed.

This release is named "ttoper".
```

```
To learn more about the release, try:

  $ helm status ttoper
  $ helm get all ttoper
  $ helm history ttoper

To rollback to a previous version of the chart, run:

  $ helm rollback ttoper <REVISION>
    - run 'helm history ttoper' for a list of revisions.

To test the operator, run:

  $ helm test ttoper
```

7. After the upgrade, do the following:
   a. Verify that the TimesTen Operator is running.

      ```
      kubectl get pods
      ```

      The output is the following:

      ```
      NAME                                 READY   STATUS    RESTARTS   AGE
      norepsamplehelm-0                    3/3     Running   0          6h38m
      norepsamplehelm-1                    3/3     Running   0          6h38m
      norepsamplehelm-2                    3/3     Running   0          6h38m
      repsamplehelm-0                      3/3     Running   0          9h
      repsamplehelm-1                      2/3     Running   0          9h
      timesten-operator-57b7949f97-xdlwl   1/1     Running   0          31s
      ```

      There is a new TimesTen Operator running.
   b. Confirm the TimesTen Operator is running the new image.

      ```
      kubectl describe deployment timesten-operator | grep Image
      ```

      The output is the following:

      ```
      Image:       container-registry.oracle.com/timesten/timesten:26.1.1.2.0
      ```

      The TimesTen Operator is running the new release.
   c. Confirm the state of the TimesTenClassic objects.

      ```
      kubectl get ttc
      ```

      The output is similar to the following:

      ```
      NAME              STATE              ACTIVE            AGE
      norepsamplehelm   AllReplicasReady   N/A               6h39m
      repsamplehelm     Normal             repsamplehelm-0   9h
      ```

The TimesTen Operator resumes the management and monitoring of the TimesTenClassic objects. The objects and the associated TimesTen databases are functioning properly.

Congratulations! You successfully upgraded the `ttoperator` chart. There is a new TimesTen Operator that is running in your namespace and it is using the new image.

Upgrade Replicated TimesTen Databases

You can upgrade a replicated TimesTen configuration, consisting of an active standby pair of TimesTen databases.

The upgrade process requires you to perform the following steps:

- Create a YAML file. In this file, you specify the container image that contains the new release of TimesTen.
- Uses the `helm values` command for the upgrade. The example shows you how to do this.

The example assumes you have created a `new_kube_files/helm/customyaml` directory.

Note

The following actions occur during an upgrade:

- The standby is terminated first. It takes some time for the standby to come back up. When the standby comes back up, it is upgraded to the new release. During the upgrade of the standby, depending on your replication configuration, there may be disruption on the active database.
- Next, the failover from the active to the standby occurs:
  - The active is terminated. It takes some time for the former active to come back up. When the active comes back up, it is upgraded to the new release.
  - The standby database is promoted to the active and the former active becomes the standby.

For more information about how TimesTen performs an upgrade of an active standby pair of TimesTen databases, see Performing an Upgrade with Active Standby Pair Replication in the *Oracle TimesTen In-Memory Database Installation, Migration, and Upgrade Guide*.

Ensure you perform an upgrade at the appropriate time. We recommend that you do not perform upgrades at the busiest time of a production day. Applications may experience short outages and perhaps reduced performance as a result of the upgrade procedure.

1. On your development host, change to the `helm` directory that contains the new Helm charts.

   ```
   cd new_kube_files/helm
   ```

2. Create a YAML file and in it specify the name of the TimesTen image you want to use for the upgrade.

   ```
   vi customyaml/upgradereplicated.yaml
   ```

```
image:
  repository: container-registry.oracle.com/timesten/timesten
  tag: "26.1.1.2.0"
```

3. Before the upgrade, do the following:
   a. Confirm the replicated TimesTenClassic object exists in your namespace.

      ```
      kubectl get ttc
      ```

      The output is similar to the following:

      ```
      NAME              STATE            ACTIVE            AGE
      norepsamplehelm   AllReplicasReady N/A               8h
      repsamplehelm     Normal           repsamplehelm-0   11h
      ```

      The `repsamplehelm` TimesTenClassic object exists and is in the `Normal` state.
   b. Verify the image.

      ```
      kubectl describe ttc repsamplehelm | grep Image
      ```

      The output is similar to the following:

      ```
      Image:      container-registry.oracle.com/timesten/timesten:26.1.1.1.0
      ...
      ```

4. Confirm the `ttclassic` chart release.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   repsamplehelm   default         1               2025-01-16
   14:58:40.109402333 +0000 UTC deployed        ttclassic-261110.1.0
   26.1.1.1.0
   ```

5. Upgrade to the new release. Use the `ttclassic` chart from the new release and use the customized YAML file that references the new image.

Note

We recommend the following syntax. This ensures existing customizations are preserved.

```
helm get values repsamplehelm --all > prev-values-repttc.yaml
```

```
helm upgrade -f prev-values-repttc.yaml -f customyaml/
upgradereplicated.yaml  repsamplehelm ./ttclassic
```

Let's look at this `helm upgrade` command:

- The `get values repsamplehelm` Helm command retrieves the values for the current release, including existing customizations. The result of this command is piped into the `prev-values-repttc.yaml` file. You can choose any name for this file.
- The `helm upgrade` command uses the `prev-values-repttc.yaml` file with the customized `upgradereplicated.yaml` file to do the upgrade.

Let's look at the output from the `helm upgrade` command.

```
Release "repsamplehelm" has been upgraded. Happy Helming!
NAME: repsamplehelm
LAST DEPLOYED: Thu Jan  16 02:25:13 2025
NAMESPACE: default
STATUS: deployed
REVISION: 2
NOTES:
Version 261120.1.0 of the ttclassic chart has been installed.

This release is named "repsamplehelm".

To learn more about the release, try:

  $ helm status repsamplehelm
  $ helm get all repsamplehelm
  $ helm history repsamplehelm

To rollback to a previous version of the chart, run:

  $ helm rollback repsamplehelm <REVISION>
    - run 'helm history repsamplehelm' for a list of revisions.
```

Note the following:

- The `repsamplehelm` chart release is upgraded. The release revision is `2`.
- The status of the release is `deployed`.
- The `ttclassic` chart version is `261120.1.0` corresponding to TimesTen release `26.1.1.2.0`.

6. Observe the automatic upgrade and how the TimesTenClassic object transitions from and to various states.

```
kubectl get events -w
```

The output is similar to the following:

```
11m         Normal    Upgrade                   timestenclassic/
repsamplehelm   Image updated, automatic upgrade started
11m         Normal    Upgrade                   timestenclassic/
repsamplehelm   Deleted standby pod repsamplehelm-1 during upgrade
11m         Warning   Failed                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 was replaced
11m         Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Not Ready
11m         Warning   StateChange               timestenclassic/
repsamplehelm   TimesTenClassic was Normal, now ActiveTakeover
11m         Normal    StateChange               timestenclassic/
repsamplehelm   TimesTenClassic was ActiveTakeover, now StandbyDown
9m26s       Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Agent Up
9m26s       Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Instance Exists
9m26s       Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Daemon Down
9m26s       Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Daemon Up
9m26s       Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database Unloaded
9m24s       Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database None
9m21s       Normal    Info                      timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 597 secs
9m18s       Normal    Info                      timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 594 secs
9m15s       Normal    Info                      timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 591 secs
9m12s       Normal    Info                      timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 588 secs
9m9s        Normal    Info                      timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 585 secs
9m6s        Normal    Info                      timestenclassic/
repsamplehelm   RepDuplicate completed in 16 secs
9m5s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database Loaded
9m5s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepAgent Not Running
9m5s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepScheme Exists
9m5s        Normal    StateChange               timestenclassic/
```

```
repsamplehelm   Pod repsamplehelm-1 RepState IDLE
9m           Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database Loaded
9m           Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepAgent Running
9m           Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepScheme Exists
9m           Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepState STANDBY
9m           Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Ready
8m59s        Normal    Upgrade                   timestenclassic/
repsamplehelm   Upgrade of standby complete
8m59s        Normal    StateChange               timestenclassic/
repsamplehelm   TimesTenClassic was StandbyDown, now Normal
8m28s        Normal    Upgrade                   timestenclassic/
repsamplehelm   Deleted active pod repsamplehelm-0 during upgrade
7m27s        Warning   Error                     timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Unreachable for 119 seconds
7m27s        Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-0 is Not Ready
7m27s        Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-0 is Not Active Ready
7m27s        Warning   StateChange               timestenclassic/
repsamplehelm   TimesTenClassic was Normal, now ActiveDown
7m27s        Warning   Failed                    timestenclassic/
repsamplehelm   Pod repsamplehelm-0 was replaced
7m26s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database Updatable
7m26s        Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepState ACTIVE
7m26s        Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Not Ready
7m26s        Normal    StateChange               timestenclassic/
repsamplehelm   TimesTenClassic was ActiveDown, now ActiveTakeover
7m21s        Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Ready
7m21s        Normal    StateChange               timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Active Ready
7m21s        Normal    StateChange               timestenclassic/
repsamplehelm   TimesTenClassic was ActiveTakeover, now StandbyDown
6m17s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Agent Up
6m17s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Instance Exists
6m17s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Daemon Down
6m16s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Daemon Up
6m16s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Database Unloaded
6m14s        Normal    Info                      timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Database None
6m11s        Normal    Info                      timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 597 secs
```

```
6m8s        Normal    Info                         timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 594 secs
6m5s        Normal    Info                         timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 591 secs
6m2s        Normal    Info                         timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 588 secs
5m59s       Normal    Info                         timestenclassic/
repsamplehelm   RepDuplicate completed in 13 secs
5m58s       Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Database Loaded
5m58s       Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepAgent Not Running
5m58s       Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepScheme Exists
5m58s       Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepState IDLE
5m53s       Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Database Loaded
5m53s       Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepAgent Running
5m53s       Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepScheme Exists
5m53s       Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepState STANDBY
5m53s       Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 is Ready
5m52s       Normal    Upgrade                      timestenclassic/
repsamplehelm   Upgrade of active complete
5m52s       Normal    Upgrade                      timestenclassic/
repsamplehelm   Upgrade completed in 350 secs
5m52s       Normal    StateChange                  timestenclassic/
repsamplehelm   TimesTenClassic was StandbyDown, now Normal
```

The automated upgrade process completes. The TimesTenClassic object is in the `Normal` state. TimesTen databases are up and running and functioning properly. Active standby pair replication is configured between them.

7. After the upgrade, do the following:

   a. Confirm the replicated TimesTenClassic object is in the `Normal` state and the active is `repsamplehelm-1`.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME            STATE     ACTIVE            AGE
   repsamplehelm   Normal    repsamplehelm-1   11h
   ```

   b. Verify the image.

   ```
   kubectl describe ttc repsamplehelm | grep Image
   ```

The output is similar to the following:

```
Image:       container-registry.oracle.com/timesten/timesten:26.1.1.2.0
...
```

8. (Optional): Use `helm test` to test TimesTen.

   ```
    helm test repsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME: repsamplehelm
   LAST DEPLOYED: Thu Jan  16 02:25:13 2025
   NAMESPACE: default
   STATUS: deployed
   REVISION: 2
   TEST SUITE:     repsamplehelm-ttclassic-test
   Last Started:   Thu Jan  16 02:49:22 2025
   Last Completed: Thu Jan  16 02:49:26 2025
   Phase:          Succeeded
   NOTES:
   Version 261120.1.0 of the ttclassic chart has been installed.

   This release is named "repsamplehelm".

   To learn more about the release, try:

     $ helm status repsamplehelm
     $ helm get all repsamplehelm
     $ helm history repsamplehelm

   To rollback to a previous version of the chart, run:

     $ helm rollback repsamplehelm <REVISION>
       - run 'helm history repsamplehelm' for a list of revisions.
   ```

   The test succeeeds.

Congratulations! You successfully completed an automated upgrade for a replicated TimesTenClassic object. The TimesTenClassic object is upgraded and is in the `Normal` state. The replicated active standby pair of TimesTen databases are running the new release and are fully operational.

Upgrade Non-Replicated TimesTen Databases

Let's perform an upgrade of a non-replicated TimesTenClassic object consisting of three independent TimesTen databases.

The upgrade process requires you to perform the following steps:

- Create a YAML file. In this file, you specify the container image that contains the new release of TimesTen.
- Use the `helm values` command for the upgrade. The example shows you how to do this.

In addition, the example shows you how to change the value for the `rollingUpdatePartition` variable.

1. On your development host, change to the `helm` directory that contains the new Helm charts.

   ```
   cd new_kube_files/helm
   ```

2. Create a YAML file and in it specify the name of the TimesTen image you want to use for the upgrade.

   ```
   vi customyaml/upgradenonreplicated.yaml

   image:
     repository: container-registry.oracle.com/timesten/timesten
     tag: "26.1.1.2.0"
   ```

3. Before the upgrade, do the following:

   a. Confirm the non-replicated TimesTenClassic object exists in your namespace.

      ```
      kubectl get ttc
      ```

      The output is similar to the following:

      ```
      NAME              STATE             ACTIVE            AGE
      norepsamplehelm   AllReplicasReady  N/A               10h
      repsamplehelm     Normal            repsamplehelm-1   13h
      ```

      The `norepsamplehelm` TimesTenClassic object exists and is in the `AllReplicasReady` state.

   b. Verify the image and the value of `rollingUpdatePartition`.

      ```
      kubectl get ttc norepsamplehelm -o yaml | grep 'image\|
      rollingUpdatePartition'
      ```

      The output is similar to the following:

      ```
          image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
      ...
          rollingUpdatePartition: 2
      ...
      ```

      The value for `rollingUpdatePartition` is `2`, indicating that Kubernetes upgrades Pods with an ordinal value greater than or equal to `2`. For the `norepsamplehelm` object, since the value of `replicas` is `3`, there are three Pods named `norepsamplehelm-0`, `norepsamplehelm-1`, and `norepsamplehelm-2`. Therefore, Kubernetes only upgrades the `norepsamplehelm-2` Pod.

4. Confirm the `ttclassic` chart release.

   ```
   helm list
   ```

The output is similar to the following:

```
NAME            NAMESPACE       REVISION
UPDATED                                 STATUS
CHART                   APP VERSION
norepsamplehelm default         1               2025-01-16
17:42:47.180635098 +0000 UTC deployed       ttclassic-261110.1.0
26.1.1.1.0
```

5. Upgrade to the new release. Use the `ttclassic` chart from the new release and use the customized YAML file that references the new image.

   Note

   We recommend the following syntax. This ensures existing customizations are preserved.

```
helm get values norepsamplehelm --all > prev-values-norepttc.yaml
```

```
helm upgrade -f prev-values-norepttc.yaml -f customyaml/
upgradenonreplicated.yaml  norepsamplehelm ./ttclassic
```

   Let's look at this `helm upgrade` command:

   - The `get values norepsamplehelm` Helm command retrieves the values for the current release, including existing customizations. The result of this command is piped into the `prev-values-norepttc.yaml` file. You can choose any name for this file.
   - The `helm upgrade` command uses the `prev-values-norepttc.yaml` file with the customized `upgradenonreplicated.yaml` file to do the upgrade.

   Let's look at the output from the `helm upgrade` command.

```
Release "norepsamplehelm" has been upgraded. Happy Helming!
NAME: norepsamplehelm
LAST DEPLOYED: Thu Jan  16 04:22:15 2025
NAMESPACE: default
STATUS: deployed
REVISION: 2
NOTES:
Version 261120.1.0 of the ttclassic chart has been installed.

This release is named "norepsamplehelm".

To learn more about the release, try:

  $ helm status norepsamplehelm
  $ helm get all norepsamplehelm
  $ helm history norepsamplehelm

To rollback to a previous version of the chart, run:
```

```
$ helm rollback norepsamplehelm <REVISION>
  - run 'helm history norepsamplehelm' for a list of revisions.
```

Note the following:

- The `norepsamplehelm` chart release is upgraded. The release revision is `2`.
- The status of the release is `deployed`.
- The `ttclassic` chart version is `261120.1.0` corresponding to TimesTen release `26.1.1.2.0`.

6. Monitor the progress.

```
kubectl get ttc norepsamplehelm
```

The output is similar to the following:

```
NAME              STATE              ACTIVE           AGE
norepsamplehelm   SomeReplicasReady  N/A              10h
```

The object is in the `SomeReplicasReady` state.

Wait a few minutes. Then, monitor again.

```
kubectl get ttc norepsamplehelm
```

The output is similar to the following:

```
NAME              STATE             ACTIVE           AGE
norepsamplehelm   AllReplicasReady  N/A              10h
```

The object is in the `AllReplicasReady` state. All replicas are ready and available. TimesTen databases are up and running and functioning properly.

7. Check the image that the `norepsamplehelm-2` Pod is running.

```
kubectl describe pod norepsamplehelm-2 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

The containers in the Pod are running the new container image.

8. Check the image for the `norepsamplehelm-1` and `norepsamplehelm-0` Pods.

   a. Check the `norepsamplehelm-1` Pod.

   ```
   kubectl describe pod norepsamplehelm-1 | grep Image
   ```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
```

The containers in the Pod are not running the new image. Due to the `rollingUpdatePartition` value of `2`, Kubernetes does not upgrade this Pod with the new image. This is correct behavior.

b. Check the `norepsamplehelm-0` Pod.

```
kubectl describe pod norepsamplehelm-0 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
```

The containers in the Pod are not running the new image. Due to the `rollingUpdatePartition` value of `2`, Kubernetes does not upgrade this Pod with the new image. This is correct behavior.

After you confirm the upgrade is working, you can upgrade the remaining Pods.

9. Create a YAML file and in it specify the `rollingUpdatePartition` variable and set the value to `0`.

```
vi customyaml/changerollingupdate.yaml

rollingUpdatePartition: 0
```

10. Change the `rollingUpdatePartition` value.

Note

We recommend the following syntax. This ensures existing customizations are preserved.

```
helm get values norepsamplehelm --all > prev-values-noreprolling.yaml &&
helm upgrade -f prev-values-noreprolling.yaml -f customyaml/
changerollingupdate.yaml  norepsamplehelm ./ttclassic
```

The output is similar to the following:

```
Release "norepsamplehelm" has been upgraded. Happy Helming!
NAME: norepsamplehelm
LAST DEPLOYED: Thu Jan  16 04:56:32 2025
NAMESPACE: default
STATUS: deployed
REVISION: 3
NOTES:
Version 261120.1.0 of the ttclassic chart has been installed.

This release is named "norepsamplehelm".

To learn more about the release, try:

  $ helm status norepsamplehelm
  $ helm get all norepsamplehelm
  $ helm history norepsamplehelm

To rollback to a previous version of the chart, run:

  $ helm rollback norepsamplehelm <REVISION>
    - run 'helm history norepsamplehelm' for a list of revisions.
```

Kubernetes automatically begins to terminate Pods and replace them with new ones. These new Pods run the new image. Since `rollingUpdatePartition` is now `0`, you should expect to see the `norepsamplehelm-1` and `norepsamplehelm-0` Pods upgraded with the new image.

11. Monitor the progress.
    a. TimesTenClassic object:

    ```
    kubectl get ttc norepsamplehelm
    ```

    The output is similar to the following

    ```
    NAME              STATE              ACTIVE   AGE
    norepsamplehelm   SomeReplicasReady  N/A      11h
    ```

    b. Pods:

    ```
    kubectl get pods
    ```

    The output is similar to the following:

    ```
    NAME                                  READY   STATUS     RESTARTS   AGE
    norepsamplehelm-0                     3/3     Running    0          11h
    norepsamplehelm-1                     0/3     Init:0/1   0          31s
    norepsamplehelm-2                     3/3     Running    0          34m
    ```

Kubernetes replaces the `norepsamplehelm-1` Pod first. Wait a few minutes. Then monitor again.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                              READY   STATUS    RESTARTS   AGE
norepsamplehelm-0                 3/3     Running   0          3m14s
norepsamplehelm-1                 3/3     Running   0          6m8s
norepsamplehelm-2                 3/3     Running   0          40m
```

Kubernetes replaced the `norepsamplehelm-1` and the `norepsamplehelm-0` Pods. All Pods are running.

12. Confirm the Pods are running the new container image.

    Pod `norepsamplehelm-1`:

    ```
    kubectl describe pod norepsamplehelm-1 | grep Image
    ```

    The output is similar to the following:

    ```
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    ```

    Pod `norepsamplehelm-0`:

    ```
    kubectl describe pod norepsamplehelm-0 | grep Image
    ```

    The output is similar to the following:

    ```
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    ```

    The Pods are running the new image.

13. Confirm the state of the TimesTenClassic object.

    ```
    kubectl get ttc norepsamplehelm
    ```

    The output is similar to the following:

    ```
    NAME              STATE              ACTIVE   AGE
    norepsamplehelm   AllReplicasReady   N/A      11h
    ```

Congratulations! You successfully performed an automated upgrade for a non-replicated TimesTenClassic object. All replicas are ready and available. Pods are running the new TimesTen container image. TimesTen databases are upgraded and fully operational.

Roll Back an Upgrade

This section shows you how to roll back a TimesTen upgrade as well as a TimesTen Operator upgrade. You cannot roll back an upgrade of TimesTen CRDs.

The section covers the following topics:

- Roll Back a Replicated TimesTen Upgrade
- Roll back a Non-Replicated TimesTen Upgrade
- Roll Back a TimesTen Operator Upgrade

Roll Back a Replicated TimesTen Upgrade

You can use Helm to roll back an upgrade of a replicated TimesTenClassic object. This reverts the replicated TimesTenClassic object and its associated TimesTen databases to the downgraded release.

Note

Ensure you perform a downgrade at the appropriate time. We recommend that you do not perform a downgrade at the busiest time of a production day. Applications may experience outages and perhaps reduced performance as a result of the downgrade procedure.

1. Before the rollback, do the following:
   a. Confirm the replicated TimesTenClassic object exists in your namespace.

      ```
      kubectl get ttc
      ```

      The output is similar to the following:

      ```
      NAME              STATE              ACTIVE            AGE
      norepsamplehelm   AllReplicasReady   N/A               19h
      repsamplehelm     Normal             repsamplehelm-1   22h
      ```

      The `repsamplehelm` TimesTenClassic object exists and is in the `Normal` state.
   b. Verify the image.

      ```
      kubectl describe ttc repsamplehelm | grep Image
      ```

      The output is similar to the following:

      ```
      Image:       container-registry.oracle.com/timesten/timesten:26.1.1.2.0
      ...
      ```

2. Review the revision history.

   ```
   helm history repsamplehelm
   ```

The output is similar to the following:

```
REVISION        UPDATED                         STATUS
CHART                   APP VERSION     DESCRIPTION
1               Thu Jan  16 14:58:40 2025        superseded
ttclassic-261110.1.0   26.1.1.1.0     Install complete
2               Fri Jan  17 02:25:13 2025        deployed
ttclassic-261120.1.0   26.1.1.2.0     Upgrade complete
```

Revision 2 of the `repsamplehelm` chart is running release `26.1.1.2.0`. Revision `1` is running release `26.1.1.1.0`.

3. Roll back to revision `1`.

   ```
   helm rollback repsamplehelm 1
   ```

   The output is the following:

   ```
   Rollback was a success! Happy Helming!
   ```

4. Observe the downgrade and how the TimesTenClassic object transitions from and to various states.

   ```
    kubectl get events -w
   ```

   The output is similar to the following:

   ```
   17m         Normal    Upgrade                  timestenclassic/
   repsamplehelm   Image updated, automatic upgrade started
   17m         Normal    Upgrade                  timestenclassic/
   repsamplehelm   Deleted standby pod repsamplehelm-0 during upgrade
   17m         Warning   Failed                   timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 was replaced
   17m         Normal    StateChange              timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 is Not Ready
   17m         Warning   StateChange              timestenclassic/
   repsamplehelm   TimesTenClassic was Normal, now ActiveTakeover
   17m         Normal    StateChange              timestenclassic/
   repsamplehelm   TimesTenClassic was ActiveTakeover, now StandbyDown
   14m         Normal    Info                     timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 Agent Up
   14m         Normal    Info                     timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 Instance Exists
   14m         Normal    Info                     timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 Daemon Down
   14m         Normal    Info                     timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 Daemon Up
   14m         Normal    Info                     timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 Database Unloaded
   14m         Normal    Info                     timestenclassic/
   repsamplehelm   Pod repsamplehelm-0 Database None
   14m         Normal    Info                     timestenclassic/
   repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
   in 597 secs
   ```

```
14m         Normal    Info                         timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 594 secs
14m         Normal    Info                         timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 591 secs
14m         Normal    Info                         timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 588 secs
14m         Normal    Info                         timestenclassic/
repsamplehelm   RepDuplicate completed in 14 secs
14m         Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Database Loaded
14m         Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepAgent Not Running
14m         Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepScheme Exists
14m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepState IDLE
14m         Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Database Loaded
14m         Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepAgent Running
14m         Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepScheme Exists
14m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepState STANDBY
14m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 is Ready
14m         Normal    Upgrade                      timestenclassic/
repsamplehelm   Upgrade of standby complete
14m         Normal    StateChange                  timestenclassic/
repsamplehelm   TimesTenClassic was StandbyDown, now Normal
14m         Normal    Upgrade                      timestenclassic/
repsamplehelm   Deleted active pod repsamplehelm-1 during upgrade
14m         Warning   Failed                       timestenclassic/
repsamplehelm   Pod repsamplehelm-1 has failed
14m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Not Ready
14m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Not Active Ready
14m         Warning   StateChange                  timestenclassic/
repsamplehelm   TimesTenClassic was Normal, now ActiveDown
13m         Warning   Failed                       timestenclassic/
repsamplehelm   Pod repsamplehelm-1 was replaced
13m         Normal    Info                         timestenclassic/
repsamplehelm   Pod repsamplehelm-0 Database Updatable
13m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 RepState ACTIVE
13m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 is Not Ready
13m         Normal    StateChange                  timestenclassic/
repsamplehelm   TimesTenClassic was ActiveDown, now ActiveTakeover
13m         Normal    StateChange                  timestenclassic/
repsamplehelm   Pod repsamplehelm-0 is Ready
13m         Normal    StateChange                  timestenclassic/
```

```
repsamplehelm   Pod repsamplehelm-0 is Active Ready
13m         Normal    StateChange             timestenclassic/
repsamplehelm   TimesTenClassic was ActiveTakeover, now StandbyDown
12m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Agent Up
12m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Instance Exists
12m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Daemon Down
12m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Daemon Up
12m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database Unloaded
12m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database None
12m         Normal    Info                    timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 597 secs
12m         Normal    Info                    timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 594 secs
11m         Normal    Info                    timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 591 secs
11m         Normal    Info                    timestenclassic/
repsamplehelm   pollAsyncStatus: Async polling for RepDuplicate, timeout
in 588 secs
11m         Normal    Info                    timestenclassic/
repsamplehelm   RepDuplicate completed in 15 secs
11m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database Loaded
11m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepAgent Not Running
11m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepScheme Exists
11m         Normal    StateChange             timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepState IDLE
11m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 Database Loaded
11m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepAgent Running
11m         Normal    Info                    timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepScheme Exists
11m         Normal    StateChange             timestenclassic/
repsamplehelm   Pod repsamplehelm-1 RepState STANDBY
11m         Normal    StateChange             timestenclassic/
repsamplehelm   Pod repsamplehelm-1 is Ready
11m         Normal    Upgrade                 timestenclassic/
repsamplehelm   Upgrade completed in 326 secs
11m         Normal    StateChange             timestenclassic/
repsamplehelm   TimesTenClassic was StandbyDown, now Normal
```

The downgrade process completes. The TimesTenClassic object is in the `Normal` state. TimesTen databases are up and running and functioning properly. Active standby pair replication is configured between them.

5. After the downgrade, do the following:
   a. Confirm the replicated TimesTenClassic object is in the `Normal` state and the active is `repsamplehelm-0`.

      ```
      kubectl get ttc
      ```

      The output is similar to the following:

      ```
      NAME            STATE     ACTIVE            AGE
      repsamplehelm   Normal    repsamplehelm-0   23h
      ```

      The object is in the `Normal` state. The active is `repsamplehelm-0`.
   b. Verify the image.

      ```
      kubectl describe ttc repsamplehelm | grep Image
      ```

      The output is similar to the following:

      ```
      Image:       container-registry.oracle.com/timesten/timesten:26.1.1.1.0
      ...
      ```

6. Check the history.

   ```
   helm history repsamplehelm
   ```

   The output is similar to the following:

   ```
   REVISION        UPDATED                         STATUS
   CHART                   APP VERSION     DESCRIPTION
   1               Thu Jan  16 14:58:40 2025        superseded
   ttclassic-261110.1.0   26.1.1.1.0      Install complete
   2               Fri Jan  17 02:25:13 2025        superseded
   ttclassic-261120.1.0   26.1.1.2.0      Upgrade complete
   3               Fri Jan  17 13:54:33 2025        deployed
   ttclassic-261110.1.0   26.1.1.1.0      Rollback to 1
   ```

   Revision `3` is downgraded.

7. Confirm the `repsamplehelm` release is downgraded.

   ```
   helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   repsamplehelm   default         3               2025-01-16
   13:54:33.909336613 +0000 UTC deployed        ttclassic-261110.1.0
   26.1.1.1.0
   ...
   ```

The repsamplehelm chart release is downgraded.

Congratulations! You successfully completed the rollback. The TimesTenClassic object is downgraded to the desired release and is in the Normal state. The replicated active standby pair of TimesTen databases are running the downgraded release and are fully operational.

Roll back a Non-Replicated TimesTen Upgrade

You can use Helm to roll back an upgrade of a non-replicated TimesTenClassic object. This reverts the non-replicated TimesTenClassic object and its associated TimesTen databases to the downgraded release.

1. Before the rollback, do the following:
   a. Confirm the non-replicated TimesTenClassic object exists in your namespace.

      ```
      kubectl get ttc
      ```

      The output is similar to the following:

      ```
      NAME             STATE            ACTIVE           AGE
      norepsamplehelm  AllReplicasReady N/A              20h
      repsamplehelm    Normal           repsamplehelm-0  23h
      ```

      The norepsamplehelm TimesTenClassic object exists and is in the AllReplicasReady state.
   b. Verify the image and the value of rollingUpdatePartition.

      ```
      kubectl get ttc norepsamplehelm -o yaml | grep 'image\|
      rollingUpdatePartition'
      ```

      The output is similar to the following:

      ```
          image: container-registry.oracle.com/timesten/timesten:26.1.1.2.0
      ...
          rollingUpdatePartition: 0
      ...
      ```

      The current value for rollingUpdatePartition is 0. However, the value used for the downgrade is the original value of rollingUpdatePartition. In the example, the original value is 2. If you roll back to the original chart release in which the rollingUpdatePartition value is 2, Kubernetes only downgrades the -2 Pod. An upcoming step illustrates this.
2. Review the revision history.

   ```
   helm history norepsamplehelm
   ```

   The output is similar to the following:

   ```
   REVISION        UPDATED                         STATUS
   CHART                   APP VERSION     DESCRIPTION
   ```

```
1               Thu Jan  16 17:42:47 2025        superseded
ttclassic-261110.1.0   26.1.1.1.0     Install complete
2               Fri Jan  17 04:22:15 2025        superseded
ttclassic-261120.1.0   26.1.1.2.0     Upgrade complete
3               Fri Jan  17 04:56:32 2025        deployed
ttclassic-261120.1.0   26.1.1.2.0     Upgrade complete
```

Revision 3 of the `norepsamplehelm` chart is running release `26.1.1.2.0`. Revision `1` is running release `26.1.1.1.0`.

3. Roll back to revision `1`.

   ```
   helm rollback norepsamplehelm 1
   ```

   The output is the following:

   ```
   Rollback was a success! Happy Helming!
   ```

4. Monitor the progress.

   ```
   kubectl get ttc norepsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME              STATE                ACTIVE   AGE
   norepsamplehelm   SomeReplicasReady    N/A      20h
   ```

   The object is in the `SomeReplicasReady` state.

   Wait a few minutes. Then, monitor again.

   ```
   kubectl get ttc norepsamplehelm
   ```

   The output is similar to the following:

   ```
   NAME              STATE               ACTIVE   AGE
   norepsamplehelm   AllReplicasReady    N/A      20h
   ```

   The object is in the `AllReplicasReady` state. All replicas are ready and available. TimesTen databases are up and running and functioning properly.

5. Check the `rollingUpdatePartition` value and the image for the Pods.

   a. Check the value of `rollingUpdatePartition`.

      ```
      kubectl get ttc norepsamplehelm -o yaml | grep rollingUpdatePartition
      ```

      The output is similar to the following:

      ```
      rollingUpdatePartition: 2
      ```

      As part of the downgrade process, the value of `rollingUpdatePartition` changes to its original value of `2`.

b. Check the norepsamplehelm-2 Pod.

```
kubectl describe pod norepsamplehelm-2 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
```

The containers in the Pod are running the downgraded image. Due to the rollingUpdatePartition value of 2, Kubernetes updated this Pod with the downgraded image. This is correct behavior.

c. Check the norepsamplehelm-1 Pod.

```
kubectl describe pod norepsamplehelm-1 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
```

The containers in the Pod are not running the downgraded image. Due to the rollingUpdatePartition value of 2, Kubernetes does not update this Pod with the downgraded image. This is correct behavior.

d. Check the norepsamplehelm-0 Pod.

```
kubectl describe pod norepsamplehelm-0 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
```

The containers in the Pod are not running the downgraded image. Due to the `rollingUpdatePartition` value of 2, Kubernetes does not updated this Pod with the downgraded image. This is correct behavior.

After you confirm the downgrade is working, you can downgrade the remaining Pods.

6. Create a new YAML file and in it specify the `rollingUpdatePartition` variable and set the value to `0`.

```
vi customyaml/changerollingupdate0.yaml

rollingUpdatePartition: 0
```

7. Change the `rollingUpdatePartition` value.

> **Note**
>
> We recommend the following syntax. This ensures existing customizations are preserved.

```
helm get values norepsamplehelm --all > prev-values-noreprolling0.yaml &&
helm upgrade -f prev-values-noreprolling0.yaml -f customyaml/
changerollingupdate0.yaml  norepsamplehelm ./ttclassic
```

The output is similar to the following:

```
Release "norepsamplehelm" has been upgraded. Happy Helming!
NAME: norepsamplehelm
LAST DEPLOYED: Fri Jan  17 15:09:42 2025
NAMESPACE: default
STATUS: deployed
REVISION: 5
NOTES:
Version 261110.1.0 of the ttclassic chart has been installed.

This release is named "norepsamplehelm".

To learn more about the release, try:

  $ helm status norepsamplehelm
  $ helm get all norepsamplehelm
  $ helm history norepsamplehelm

To rollback to a previous version of the chart, run:

  $ helm rollback norepsamplehelm <REVISION>
    - run 'helm history norepsamplehelm' for a list of revisions.
```

Kubernetes automatically begins to terminate Pods and replace them with new ones. These new Pods run the downgraded image. Since `rollingUpdatePartition` is now `0`, you should expect to see the `norepsamplehelm-1` and `norepsamplehelm-0` Pods updated with the downgraded image.

8. Monitor the progress.

a. TimesTenClassic object:

```
kubectl get ttc norepsamplehelm
```

The output is similar to the following

```
NAME               STATE               ACTIVE             AGE
norepsamplehelm    SomeReplicasReady   N/A                21h
```

b. Pods:

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                  READY   STATUS      RESTARTS
AGE
norepsamplehelm-0                     3/3     Running     0
10h
norepsamplehelm-1                     0/3     Init:0/1    0
73s
norepsamplehelm-2                     3/3     Running     0
34m
```

Kubernetes replaces the `norepsamplehelm-1` Pod first. Wait a few minutes. Then monitor again.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                  READY   STATUS     RESTARTS
AGE
norepsamplehelm-0                     3/3     Running    0
7m24s
norepsamplehelm-1                     3/3     Running    0
9m49s
norepsamplehelm-2                     3/3     Running    0
42m
```

Kubernetes replaced the `norepsamplehelm-1` and the `norepsamplehelm-0` Pods. All Pods are running.

9. Confirm the Pods are running the downgraded container image.

Pod `norepsamplehelm-1`:

```
kubectl describe pod norepsamplehelm-1 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
```

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
```

Pod `norepsamplehelm-0`:

```
kubectl describe pod norepsamplehelm-0 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.1.0
```

The Pods are running the new image.

10. Confirm the value of `rollingUpdatePartition`.

```
kubectl get ttc norepsamplehelm -o yaml | grep rollingUpdatePartition
```

The output is similar to the following:

```
rollingUpdatePartition: 0
```

11. Confirm the state of the TimesTenClassic object.

```
kubectl get ttc norepsamplehelm
```

The output is similar to the following:

```
NAME               STATE              ACTIVE    AGE
norepsamplehelm    AllReplicasReady   N/A       21h
```

12. Check the history.

```
helm history norepsamplehelm
```

The output is similar to the following:

```
REVISION        UPDATED                         STATUS
CHART                   APP VERSION     DESCRIPTION
1               Thu Jan  16 17:42:47 2025        superseded
ttclassic-261110.1.0   26.1.1.1.0     Install complete
2               Fri Jan  17 04:22:15 2025        superseded
ttclassic-261120.1.0   26.1.1.2.0     Upgrade complete
3               Fri Jan  17 04:56:32 2025        superseded
ttclassic-261120.1.0   26.1.1.2.0     Upgrade complete
4               Fri Jan  17 14:36:43 2025        superseded
ttclassic-261110.1.0   26.1.1.1.0     Rollback to 1
5               Fri Jan  17 15:09:42 2025        deployed
ttclassic-261110.1.0   26.1.1.1.0     Upgrade complete
```

Revision 5 is running the 261110.1.0 chart.

13. Confirm the norepsamplehelm release is downgraded.

```
helm list
```

The output is similar to the following:

```
NAME            NAMESPACE       REVISION
UPDATED                                 STATUS
CHART                   APP VERSION
norepsamplehelm default         5               2025-01-07
15:09:42.959017268 +0000 UTC deployed        ttclassic-261110.1.0
26.1.1.1.0
```

The norepsamplehelm chart release is downgraded.

Congratulations! You successfully completed the rollback. The TimesTenClassic object is downgraded to the desired release and is in the AllReplicasReady state. All replicas are ready and available. Pods are running the downgraded TimesTen container image. TimesTen databases are upgraded and fully operational.

Roll Back a TimesTen Operator Upgrade

You can use Helm to roll back an upgrade of the TimesTen Operator.

1. Before the rollback, do the following:
   a. Confirm the TimesTen Operator is running in your namespace.

      ```
      kubectl get pods
      ```

      The output is similar to the following:

      ```
      NAME                                 READY   STATUS     RESTARTS
      AGE
      ...
      timesten-operator-57b7949f97-xdlwl   1/1     Running    0
      15h
      ```

      The TimesTen Operator is running in your namespace.
   b. Verify the image.

      ```
       kubectl describe deployment timesten-operator | grep Image
      ```

      The output is similar to the following:

      ```
      Image:       container-registry.oracle.com/timesten/timesten:26.1.1.2.0
      ```

2. Review the current release of the TimesTen Operator chart.

   ```
   helm list
   ```

The output is similar to the following:

```
NAME            NAMESPACE       REVISION
UPDATED                                 STATUS
CHART                   APP VERSION
...
ttoper          default         2               2025-01-16
00:20:34.757004974 +0000 UTC deployed        ttoperator-261120.1.0
26.1.1.2.0
```

The chart's release is `26.1.1.2.0.1.0`.

3. Review the revision history.

   ```
   helm history ttoper
   ```

   The output is similar to the following:

   ```
   REVISION        UPDATED                         STATUS
   CHART                   APP VERSION     DESCRIPTION
   1               Thu Jan  16 02:54:39 2025       superseded
   ttoperator-261110.1.0  26.1.1.1.0     Install complete
   2               Fri Jan  17 00:20:34 2025       deployed
   ttoperator-261120.1.0  26.1.1.2.0     Upgrade complete
   ```

   Revision `2` of the `ttoper` chart is running release `26.1.1.2.0`. Revision `1` is running release `26.1.1.1.0`.

4. Roll back to revision `1`.

   ```
   helm rollback ttoper 1
   ```

   Output.

   ```
   Rollback was a success! Happy Helming!
   ```

5. After the downgrade, do the following:

   a. Verify that the TimesTen Operator is running.

      ```
      kubectl get pods
      ```

      The output is similar to the following:

      ```
      NAME                                 READY   STATUS    RESTARTS    AGE
      ...
      timesten-operator-55c6f99-2djfr   1/1     Running   0           4m13s
      ```

      There is a new TimesTen Operator running.

   b. Confirm the TimesTen Operator is running the downgraded image.

      ```
      kubectl describe deployment timesten-operator | grep Image
      ```

The output is the following:

```
Image:       container-registry.oracle.com/timesten/timesten:26.1.1.1.0
```

The TimesTen Operator is running the downgraded release.

c. Confirm the state of the TimesTenClassic objects.

```
kubectl get ttc
```

The output is similar to the following:

```
NAME              STATE              ACTIVE            AGE
norepsamplehelm   AllReplicasReady   N/A               22h
repsamplehelm     Normal             repsamplehelm-0   25h
```

The TimesTen Operator resumes the management and monitoring of the TimesTenClassic objects. The objects and the associated TimesTen databases are functioning properly.

6. Confirm the revision history.

```
helm history ttoper
```

The output is similar to the following:

```
REVISION        UPDATED                         STATUS
CHART                   APP VERSION     DESCRIPTION
1               Thu Jan  16 02:54:39 2025        superseded
ttoperator-261110.1.0  26.1.1.1.0     Install complete
2               Fri Jan  16 00:20:34 2025        superseded
ttoperator-261120.1.0  26.1.1.2.0     Upgrade complete
3               Fri Jan  17 16:11:37 2025        deployed
ttoperator-261110.1.0  26.1.1.1.0     Rollback to 1
```

Revision 3 of the chart is running release 261110.

7. Confirm the chart's release is downgraded.

```
helm list
```

The output is similar to the following:

```
NAME            NAMESPACE       REVISION
UPDATED                                 STATUS
CHART                   APP VERSION
...
ttoper          default         3               2025-01-17
16:11:37.408437395 +0000 UTC deployed        ttoperator-261110.1.0
26.1.1.1.0
```

The chart contains the correct release.

Congratulations! You successfully completed the rollback. The TimesTen Operator is using the downgraded image and is functioning properly. It has resumed management and monitoring of TimesTenClassic objects.

Clean Up

This section shows you how to delete replicated and non-replicated TimesTenClassic objects and associated databases from your namespace. It also shows you how to delete the TimesTen Operator Deployment and TimesTen CRDs. It covers the following topics:

- About Uninstalling a Release
- Delete TimesTen Databases
- Delete the TimesTen Operator
- Delete the TimesTen CRDs

About Uninstalling a Release

You can uninstall a release by using the `helm uninstall` command. This command deletes the Kubernetes objects created by the `helm install` command. Uninstalling a release results in TimesTen databases being deleted or being unmanaged or both. You can also uninstall the TimesTen Operator and the TimesTen CRDs. If you uninstall TimesTen CRDs, Kubernetes deletes the CRDs along with all TimesTenClassic objects associated with the CRDs.

The examples are for demonstration purposes.

Delete TimesTen Databases

You can uninstall replicated and non-replicated TimesTenClassic objects. This results in the deletion of TimesTen databases associated with the object. Since the Persistent Volume Claims (PVCs) are not automatically deleted, you must manually delete them. The example shows you how to do this.

1. Confirm the TimesTenClassic objects that are running in your namespace.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME             STATE             ACTIVE           AGE
   norepsamplehelm  AllReplicasReady  N/A              24h
   repsamplehelm    Normal            repsamplehelm-0  27h
   ```

2. List the releases.

   ```
    helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   ```

```
norepsamplehelm default         5               2025-01-16
15:09:42.959017268 +0000 UTC deployed        ttclassic-261110.1.0
26.1.1.1.0
repsamplehelm   default         3               2025-01-16
13:54:33.909336613 +0000 UTC deployed        ttclassic-261110.1.0
26.1.1.1.0
ttoper          default         3               2025-01-16
16:11:37.408437395 +0000 UTC deployed        ttoperator-261110.1.0
26.1.1.1.0
```

The `norepsamplehelm` and `repsamplehelm` releases exist in your namespace.

3. Uninstall the release for the replicated TimesTenClassic object.
   a. Uninstall.

      ```
      helm uninstall repsamplehelm
      ```

      The output is the following:

      ```
      release "repsamplehelm" uninstalled
      ```

   b. Confirm the TimesTenClassic object no longer exists.

      ```
      kubectl get ttc repsamplehelm
      ```

      The output is the following:

      ```
      Error from server (NotFound): timestenclassics.timesten.oracle.com
      "repsamplehelm" not found
      ```

   c. Confirm the ConfigMap is deleted.

      ```
      kubectl get configmap repsamplehelm
      ```

      The output is the following:

      ```
      Error from server (NotFound): configmaps "repsamplehelm" not found
      ```

   d. Delete the PVCs.

      ```
      kubectl get pvc
      ```

      The output is the following:

      ```
      NAME                              STATUS
      VOLUME                                     CAPACITY   ACCESS MODES
      STORAGECLASS   AGE
      tt-persistent-repsamplehelm-0     Bound     csi-4ef3c13e-ae49-4604-8586-
      b78343142481   50Gi       RWO            oci-bv         28h
      tt-persistent-repsamplehelm-1     Bound
      csi-6786e82d-0bde-458f-8acd-047308e391a0   50Gi       RWO
      ```

```
oci-bv         28h
...
```

Delete:

```
kubectl delete pvc tt-persistent-repsamplehelm-0
```

```
kubectl delete pvc tt-persistent-repsamplehelm-1
```

4. Uninstall the release for the non-replicated TimesTenClassic objects.
   a. Uninstall.

      ```
      helm uninstall norepsamplehelm
      ```

      The output is the following:

      ```
      release "norepsamplehelm" uninstalled
      ```

   b. Confirm the TimesTenClassic object no longer exists.

      ```
      kubectl get ttc norepsamplehelm
      ```

      The output is the following:

      ```
      Error from server (NotFound): timestenclassics.timesten.oracle.com
      "norepsamplehelm" not found
      ```

   c. Confirm the ConfigMap is deleted.

      ```
      kubectl get configmap repsamplehelm
      ```

      The output is the following:

      ```
      Error from server (NotFound): configmaps "norepsamplehelm" not found
      ```

   d. Delete the PVCs.

      ```
      kubectl get pvc
      ```

      The output is the following:

      ```
      NAME                              STATUS
      VOLUME                                     CAPACITY   ACCESS MODES
      STORAGECLASS   AGE
      tt-persistent-norepsamplehelm-0   Bound    csi-b5302a0c-f533-418e-a152-
      a9399ed2be7b   50Gi       RWO          oci-bv         25h
      tt-persistent-norepsamplehelm-1   Bound    csi-cb4b0e04-16f1-4e87-
      a952-781ac213ff77   50Gi       RWO          oci-bv         25h
      tt-persistent-norepsamplehelm-2   Bound    csi-353d4f18-50fe-4bd6-8d57-
      fe17b973e0be   50Gi       RWO          oci-bv         25h
      ```

Delete:

```
kubectl delete pvc tt-persistent-norepsamplehelm-0
```

```
kubectl delete pvc tt-persistent-norepsamplehelm-1
```

```
kubectl delete pvc tt-persistent-norepsamplehelm-2
```

You successfully deleted the TimesTenClassic objects and associated databases from your namespace.

Delete the TimesTen Operator

You can uninstall the TimesTen Operator from your namespace.

1. Confirm the TimesTen Operator is running.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                              READY   STATUS    RESTARTS   AGE
   timesten-operator-55c6f99-2djfr   1/1     Running   0          3h1m
   ```

2. List the release.

   ```
    helm list
   ```

   The output is similar to the following:

   ```
   NAME            NAMESPACE       REVISION
   UPDATED                                 STATUS
   CHART                   APP VERSION
   ttoper          default         3               2025-01-16
   16:11:37.408437395 +0000 UTC deployed        ttoperator-261110.1.0
   26.1.1.1.0
   ```

   The `ttoper` release exists in your namespace.

3. Uninstall.

   ```
   helm uninstall ttoper
   ```

   The output is similar to the following:

   ```
   release "ttoper" uninstalled
   ```

4. Confirm the TimesTen Operator Pod is deleted.

   ```
   kubectl get pods
   ```

The output is similar to the following:

```
No resources found in default namespace.
```

5. Confirm the TimesTen Operator Deployment is deleted.

```
kubectl get deployment timesten-operator
```

The output is similar to the following:

```
Error from server (NotFound): deployments.apps "timesten-operator" not
found
```

You successfully deleted The TimesTen Operator. It is no longer running in your namespace.

Delete the TimesTen CRDs

You can delete TimesTen CRDs from your cluster.

Note

Use caution when deleting the TimesTen CRDs. This action causes the deletion of all TimesTenClassic objects and associated databases that are running in all namespaces.

1. List the release.

```
 helm list
```

The output is similar to the following:

```
NAME    NAMESPACE       REVISION
UPDATED                                 STATUS    CHART
APP VERSION
ttcrd   default         2               2025-01-16 19:07:52.249429601
+0000 UTC deployed ttcrd-261120.1.0       26.1.1.2.0
```

2. Uninstall.

```
helm uninstall ttcrd
```

The output is similar to the following:

```
release "ttcrd" uninstalled
```

3. Confirm the TimesTen CRDs no longer exist in the cluster.

```
kubectl get crd | grep timesten
```

You successfully deleted the TimesTen CRDs.

9
Use TimesTen Databases

This chapter explains how to use direct mode applications and Client/Server drivers to access and use TimesTen Classic databases.

Topics:

About Using Direct Mode Applications

You can run direct mode applications inside of the Pods in TimesTenClassic deployments. For information on direct mode applications, see Managing TimesTen Databases in the *Oracle TimesTen In-Memory Database Operations Guide*.

TimesTen Pods are created with the Kubernetes *shareProcessNamespace* option. This option allows direct mode applications running in other containers within the same Pod to function properly.

Note

The standard security issues that surround direct mode apply in this environment as in a non-Kubernetes environment. Segregating your applications into separate containers from TimesTen is intended for ease of management and ease of upgrade. It is not intended as a security barrier and provides no additional security.

Use the `.spec.template.spec.containers` attribute of your TimesTenClassic object to cause one or more containers to be created within each of the TimesTen Pods that runs the `tt` container. Such containers are created in addition to the `tt` container that runs TimesTen.

This example illustrates how to include the `.spec.template.spec.containers` attribute in your TimesTenClassic object definition.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: directmode
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 250Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    dbConfigMap:
    - directmode
  template:
    spec:
      containers:
      - name: yourapp
      image: phx.ocir.io/youraccount/yourapplication:2
      command: ["/bin/yourapp"]
    - name: anotherapp
      image: phx.ocir.io/youraccount/anotherapplication:2
      command: ["/bin/anotherapp"]
```

You can specify any other Kubernetes configuration for these containers.

The Operator automatically adds appropriate mounts to the containers. This gives your containers the ability to access TimesTen.

To use TimesTen in direct mode, your application containers must know how TimesTen is configured in the `tt` container. You must configure your application containers similarly.

In particular:

- You must know the name of the TimesTen users group. If you are using a container image located at `container-registry.oracle.com/timesten`, the name of the TimesTen users group is `timesten`. If you built the TimesTen container image, and changed the `timesten` default, ensure you use the name you used when you built the container image.
- You must know the name of the Linux operating system user that runs TimesTen. The default is `timesten`. As was mentioned in the previous bullet, if you changed this default, ensure you use the name you used when you built the container image.
- You must configure your application containers to run your applications as a member of the TimesTen users group. Only members of this group can run TimesTen in direct mode.
- You can run your direct mode applications as a user with the same UID as that of the TimesTen user that runs TimesTen (`3429` is the default) . However, this grants the application instance administrator permissions on the TimesTen instance. Alternatively, you can create a group with the same GID as that of the TimesTen users group of and then create a user whose primary or secondary group is that group, but with a UID that is not the UID of the TimesTen user that is running TimesTen. In this case, you can run your application as this user and also use TimesTen in direct mode. You can then grant this user privileges up to and including the `ADMIN` privilege. For more information on primary and secondary groups, see Creating an Installation on Linux/UNIX in the *Oracle TimesTen In-Memory Database Installation, Migration, and Upgrade Guide*. For information on TimesTen privileges, see System Privileges and Object Privileges in the *Oracle TimesTen In-Memory Database SQL Reference*.
- The direct mode application must use the TimesTen instance that is configured at `/tt/home/timesten/instances/instance1`. The scripts to configure the TimesTen environment variables are located at `/tt/home/timesten/instances/instance1/bin/ttenv.*`.
- Do not modify any file that is located in the TimesTen instance. In addition, ensure you do not create any new files in the `$TIMESTEN_HOME` directory tree of the instance.
- Do not add entries to the `/tt/home/timesten/instances/instance1/conf/sys.odbc.ini` file. These files can be overwritten by the Operator. However, you can store your own DSN entries in the `$HOME/.odbc.ini` file located in your application container.
- Do not create additional TimesTen databases.

Kubernetes, not the Operator, is responsible for monitoring and managing the life cycle of the direct mode containers. In particular:

- Applications are started by Kubernetes regardless of the state of TimesTen (located in its own container). Kubernetes manages the life cycle of containers individually. It does not sequence. Your application must know how to wait for TimesTen to become available.

- For replicated TimesTenClassic objects, a direct mode application runs in the Pod containing the active TimesTen database and in the Pod containing the standby TimesTen database. The application may need to use the `ttRepStateGet` built-in procedure to determine whether it is running on the active or on the standby and perhaps quiesce itself on the standby. For more information on the `ttRepStateGet` built-in procedure, see ttRepStateGet in the *Oracle TimesTen In-Memory Database Reference*.
- Kubernetes may start the application before the TimesTen database exists or before it is loaded into memory and ready for use. It is the responsibility of the direct mode application to verify the state of the TimesTen database in its Pod and to use it appropriately.
- If your application exits, the container terminates, and Kubernetes spawns another container. This does not impact TimesTen that is running in the `tt` container.

About Using Client/Server Drivers

Applications that are running in other Pods in your Kubernetes cluster can use your TimesTen database by using the standard TimesTen Client/Server drivers. You must configure your application containers with a TimesTen client instance. That instance must contain a configured `$TIMESTEN_HOME/conf/sys.odbc.ini` file, or your application must use an appropriate Client/Server connection string.

If you chose to configure a `sys.odbc.ini` file, the contents of `sys.odbc.ini` contains a client DSN definition that references the Pods that are running your TimesTen databases. .

This example creates the `sample` DSN and references the `sample` TimesTenClassic object in the `mynamespace` namespace.

```
% vi $TIMESTEN_HOME/conf/sys.odbc.ini

[sample]
TTC_SERVER_DSN=sample
TTC_SERVER1=sample-0.sample.mynamespace.svc.cluster.local
TTC_SERVER2=sample-1.sample.mynamespace.svc.cluster.local
```

Applications connect to the TimesTen database using this DSN. In a TimesTen Classic active standby pair configuration, TimesTen automatically routes application connections to the active database.

Client/Server applications must connect to the database using a defined username and password. The Operator can create such a user with `ADMIN` privileges. You can then connect to the database as that user to create other users and grant those users the `CREATE SESSION` privilege. See Overview of Configuration Metadata and Kubernetes Facilities.

In this example, use a connection string to connect to the `sample` database as the `sampleuser` user. (If you use a connection string that requires all the required connection attributes, you do not need to define them in the `sys.odbc.ini` file.) The `sampleuser` user was created by the Operator and already exists in the `sample` database. After connecting, you can verify that the `sampleuser.emp` table exists. (The Operator also previously created this table. See schema.sql for information on how the Operator created this table.)

```
% ttIsqlCS -connstr "TTC_SERVER1=sample-0.sample.mynamespace.svc.cluster.local;
TTC_SERVER2=sample-1.sample.mynamespace.svc.cluster.local;
TTC_SERVER_DSN=sample;UID=sampleuser;PWD=samplepw";


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reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.
```

```
connect "TTC_SERVER1=sample-0.sample.mynamespace.svc.cluster.local;
TTC_SERVER_DSN=sample;uid=sampleuser;pwd=********";
Connection successful:
DSN=;TTC_SERVER=sample-0.sample.mynamespace.svc.cluster.local;
TTC_SERVER_DSN=sample;UID=sampleuser;DATASTORE=/tt/home/timesten/datastore/sample;
DATABASECHARACTERSET=AL32UTF8;CONNECTIONCHARACTERSET=AL32UTF8;PERMSIZE=200;
DDLREPLICATIONLEVEL=3;
(Default setting AutoCommit=1)
Command> tables;
  SAMPLEUSER.EMP
1 table found.
```

If you are using TimesTen client/server from applications within your Kubernetes cluster, you do not have to list all the TimesTen Pods in your connection string. Instead, you can create a Kubernetes Service that routes incoming client connections to ready instances. For this Service to work correctly, you need to use a readiness probe.

If you are using TimesTen client/server from applications outside your Kubernetes cluster, you must use a Kubernetes NodePort Service and a readiness probe.

For more information:

- About readiness probes: See About Readiness Probes for TimesTen Containers in this book.
- About Kubernetes Services: See Kubernetes Services in the Kubernetes documentation.
- About NodePort Service: See NodePort Service in the Kubernetes documentation.
- About TimesTen client instances, see Creating a TimesTen Client Instance in the *Oracle TimesTen In-Memory Database Installation, Migration, and Upgrade Guide*.

10

Manage and Monitor TimesTen Classic Databases

The TimesTen Operator maintains high level states for TimesTenClassic objects and TimesTen Pods. These states describe the health of TimesTenClassic objects and the health of TimesTen databases in Pods.

Let's learn about these states and let's learn about some manual operations you can perform.

Topics:

About the High Level State of TimesTenClassic Objects

The TimesTen Operator keeps track of the high level state of TimesTenClassic objects in replicated and non-replicated configurations. For replicated TimesTenClassic objects, the high level state describes the TimesTen databases in an active standby pair. Since each TimesTen database in a non-replicated configuration is independent, the high level state for non-replicated TimesTenClassic object describes the health of the replicas of TimesTen databases. For example, if all replicas for the TimesTenClassic object are up and running and functioning properly, the high level state is `AllReplicasReady`. Use `kubectl get events` or `kubectl get ttc` to monitor the state of TimesTenClassic objects.

The following table shows the high level states for TimesTenClassic objects and indicates if the state is supported for replicated or non-replicated objects or both:

State	Replicated Objects	Non-Replicated Objects
ActiveDown	Y	N
ActiveTakeover	Y	N
AllReplicasReady	N	Y
BothDown	Y	N
ConfiguringActive	Y	N
Failed	Y	Y
Initializing	Y	Y
ManualInterventionRequired	Y	Y
NoReplicasReady	N	Y

State	Replicated Objects	Non-Replicated Objects
Normal	Y	N
Reexamine	Y	Y
SomeReplicasReady	N	Y
StandbyCatchup	Y	N
StandbyDown	Y	N
StandbyStarting	Y	N
WaitingForActive	Y	N

ActiveDown

If the TimesTen Operator detects that TimesTen in the Pod containing the active database has failed, then the TimesTenClassic object immediately enters the `ActiveDown` state.

The `unreachableTimeout` timeout value controls how long the state of the Pod containing the active database can be `Unknown` before the TimesTenClassic object's state becomes `ActiveDown`.

When the TimesTenClassic object's state becomes `ActiveDown`, the standby database immediately becomes the active, and the state of the TimesTenClassic object becomes `StandbyDown`.

ActiveTakeover

When the TimesTenClassic object is in the `Normal` state, and the standby database goes down, the state briefly changes to `ActiveTakeover`.

When AWT cache groups are used, the standby is normally responsible for pushing updates from TimesTen to Oracle Database. However, if the standby fails, the active database takes over this responsibility. This occurs during the `ActiveTakeover` state.

AllReplicasReady

For a non-replicated TimesTenClassic object, all replicas are ready and available. The TimesTen databases are up and running and functioning properly.

BothDown

Neither the active nor the standby database is functioning properly. The TimesTen Operator attempts to bring up the pair of databases.

If both Pods in the active standby pair fail, the TimesTen Operator uses the information in TimesTenClassicStatus to minimize data loss. See About the BothDown State.

ConfiguringActive

When the TimesTenClassic object is in the `WaitingForActive` state, and when the database that should be the active database comes up, the TimesTenClassic object enters the `ConfiguringActive` state. The TimesTen Operator then configures this database to be the active. Once the database is configured as the active, the TimesTenClassic object enters the `StandbyDown` state. See About the BothDown State.

Failed

If a problem occurs while `Initializing` a TimesTenClassic object, the object transitions to the `Failed` state. Once in this state, the TimesTen Operator does not attempt to repair the object. You must delete it. Use the `kubectl get events` command to determine the cause of the problem and then recreate the object.

Initializing

After you create a TimesTenClassic object, the TimesTen Operator creates the Kubernetes StatefulSets and Secrets that are required for the TimesTenClassic object. As the TimesTen Pods are starting up, the TimesTen Operator assigns the `initializing` state to the TimesTenClassic object.

ManualInterventionRequired

When a TimesTenClassic object enters the `ManualInterventionRequired` state, the TimesTen Operator takes no further action for the object. It does not query the TimesTen agents associated with the object to determine the state of TimesTen and it does not command TimesTen to do anything.

For replicated TimesTenClassic objects, see About the ManualInterventionRequired State for Replicated Objects and About Bringing Up One Database.

NoReplicasReady

For a non-replicated TimesTenClassic object, there are no replicas ready or available. TimesTen databases are not running.

Normal

For replicated objects, the `Normal` state indicates that TimesTen databases are up and running and functioning properly.

Reexamine

When a TimesTenClassic object is in the `ManualInterventionRequired` state, you can specify the `.spec.ttspec.reexamine` datum to cause the TimesTen Operator to take over management of the object. The TimesTen Operator moves the object to the `Reexamine` state. The Operator then examines the state of TimesTen.

For a replicated TimesTen Classic object, the TimesTen Operator does the following:

- If you correctly repaired TimesTen, the Operator moves the TimesTenClassic object to either the `Normal` or `StandbyDown` state, depending on the nature of your repair.
- If you did not correctly repair TimesTen, the Operator moves the TimesTenClassic object to the `ManualInterventionRequired` state.

For a non-replicated TimesTenClassic object, the TimesTen Operator does the following:

- If you correctly repaired TimesTen, the Operator moves the TimesTenClassic object to the `AllReplicasReady` state.
- If you did not correctly repair TimesTen, the Operator moves the TimesTenClassic object to the `ManualInterventionRequired` state.

SomeReplicasReady

For a non-replicated TimesTenClassic object, some but not all replicas are ready and available.

StandbyCatchup

This state is entered after the `StandbyStarting` state. During the `StandbyStarting` state, the standby copies the active database to the standby Pod. When the duplicate process is complete, the state changes from `StandbyStarting` to `StandbyCatchup`. See StandbyStarting. In the `StandbyCatchup` state, the duplicate process has completed. Transactions that ran during this duplicate process must now be copied over to the standby. Thus the `StandbyCatchup` state is the state when the newly created standby catches up to any transactions that ran on the active while the duplicate operation was running. Applications can continue to use the active without restriction.

StandbyDown

The active database is functioning properly, but the standby database is not. The TimesTen Operator automatically attempts to restart and reconfigure the standby database. Applications can continue to use the active database without restriction.

StandbyStarting

The standby is duplicating the database from the active. The `StandbyStarting` state is complete when the duplicate operation completes. The `StandbyCatchup` state is then entered. See StandbyCatchup. Applications can continue to use the active without restriction.

WaitingForActive

When the TimesTenClassic object is in the `BothDown` state, if the TimesTen Operator can determine which database contains the most up-to-date data, the TimesTenClassic object enters the `WaitingForActive` state. The object remains in this state until the Pod that contains the database is running, and the TimesTen agent within the `tt` container (within that Pod) is responding to the TimesTen Operator. See About the BothDown State.

About the High Level State of TimesTen Pods

The TimesTen Operator keeps track of the individual health and state of each TimesTen Pod. How often the Operator checks the health is defined by the value of the `pollingInterval`. For information on `pollingInterval`, see TimesTenClassicSpecSpec

The TimesTen Operator maintains similar states for replicated and non-replicated objects. However, the values for the states may differ. The following table indicates if the state is supported for replicated or non-replicated objects or both:

State	Replicated Objects	Non-Replicated Objects
CatchingUp	Y	N
Down	Y	Y
Healthy	Y	N
HealthyActive	Y	N
HealthyStandby	Y	N
Initializing	Y	Y
ManualInterventionRequired	N	Y
Normal	Y	Y
OtherDown	Y	N
Reexamine	N	Y
Terminal	Y	Y
Unknown	Y	Y
UpgradeFailed	Y	N

CatchingUp

The standby has completed the process of duplicating the database from the active. The newly created standby is catching up to any transactions that ran on the active while the duplicate operation was running.

Down

Either the Pod or the TimesTen components within the Pod (or both) are not functioning properly.

Healthy

The Pod and the TimesTen components within the Pod are in a healthy state, given this Pod's role in the active standby pair.

HealthyActive

When a TimesTenClassic object is in the `Reexamine` state, the TimesTen Operator examines the state of both TimesTen instances. The TimesTen Operator does not know which instance (if any) contains a properly configured active database (or a properly configured standby database). The Operator must examine both instances to see. If a healthy instance is found and that instance contains a properly configured active database, the state of the Pod is reported as `HealthyActive`.

HealthyStandby

When a TimesTenClassic object is in the `Reexamine` state, the TimesTen Operator examines the state of both TimesTen instances. The TimesTen Operator does not know which instance (if any) contains a properly configured standby database (or a properly configured active database). The Operator must examine both instances to see. If a healthy instance is found and that instance contains a properly configured standby database, the state of the Pod is reported as `HealthyStandby`.

Initializing

When a new Pod and PVC are started by Kubernetes as part of a TimesTenClassic object's StatefulSet, the TimesTen Operator instructs the TimesTen Agent to perform the following actions in the `tt` container of the Pod:

- Create a TimesTen installation.
- Create a TimesTen instance. This instance uses the installation that was created.
- Create TimesTen configuration files in the instance.
- Start the TimesTen instance.
- Create a TimesTen database.
- If applicable, create database users.
- If applicable, create database schemas, tables, views, procedures and other database objects.

While the previous operations are running, the state of the TimesTen Pod is `Initializing`. If these operations complete successfully, the TimesTen Operator changes the TimesTen Pod state to `Normal`. If any of the operations fail, the TimesTen Operator changes the state to `Terminal`.

ManualInterventionRequired

For non-replicated objects, when a TimesTen Pod enters the `ManualInterventionRequired` state, the TimesTen Operator does not know the state of TimesTen or the TimesTen databases. The TimesTen Operator takes no further action. Examine the TimesTen Pods and the TimesTenClassic object. When you have corrected the problem, you can instruct the TimesTen Operator to move the object and TimesTen Pods to the `Reexamine` state.

Normal

When a new Pod and PVC are started by Kubernetes as part of a TimesTenClassic object's StatefulSet, the TimesTen Operator instructs the TimesTen Agent to perform various actions in the `tt` container of the Pod. While these actions are being performed, the state is Initializing. If the operations complete successfully, the TimesTen Operator changes the TimesTen Pod state to `Normal`.

OtherDown

The Pod and the TimesTen components within the Pod are in a healthy state, but TimesTen in this Pod believes that TimesTen in the other Pod has failed. In particular, the `OtherDown` state indicates that this Pod contains an active database, and the database's peer has reached the `failThreshold`. The database in this Pod is no longer keeping transaction logs for its peer, as the peer is too far behind. Recovering the peer requires re-duplicating the active database, which the TimesTen Operator performs automatically.

Reexamine

For non-replicated objects, when a TimesTen object is in the `ManualInterventionRequired` state, you can specify the `.spec.ttspec.reexamine` datum to cause the TimesTen Operator to take over management of the object. The TimesTen Operator moves the object to the `Reexamine` state. The Operator then examines the state of TimesTen and the TimesTen databases in the Pods.

Based on the examination, the TimesTen Operator does the following:

- If healthy, the Operator moves the TimesTenClassic object to the `AllReplicasReady` state and the TimesTen Pods to the `Normal` state.
- If not healthy, the Operator moves the TimesTenClassic object and the unhealthy Pods to the `ManualInterventionRequired` state.

Terminal

The TimesTen Operator is unable to repair TimesTen in a Pod.

Unknown

The state of this Pod is unknown. Either the Pod is unreachable or the TimesTen agent contained within the Pod has failed.

UpgradeFailed

For replicated objects, an automated upgrade was attempted on TimesTen in this Pod and the upgrade failed. See About Upgrading TimesTen Classic Databases.

About the BothDown State

In replicated configurations, the TimesTen Operator provisions, monitors, and manages active standby pairs of TimesTen databases. It detects and reacts to the failure of the active or the standby database. For example, when one database in the active standby pair is down, the TimesTen Operator does the following:

- If the active database fails, the Operator promotes the standby to be the active.
- If the standby database fails, the Operator keeps the active running and repairs the standby.

However, if both databases fail at the same time, it is essential that the databases are brought back up appropriately. TimesTen replication does not atomically commit transactions in both database simultaneously. Transactions are committed in one database and then later are committed in the other database. (The database on which transactions are committed first is considered the database that is *ahead*.) Depending on how replication is configured, transactions on the active database may be ahead of the standby or the standby may be ahead of the active. To avoid data loss, the database that is ahead must become the active database after the failure is corrected.

In most cases, the TimesTen Operator can determine which database was ahead at the time of the failure. However, there are cases where the Operator cannot determine which database was ahead. In particular, the Operator cannot determine which database is ahead if all of the following conditions occur:

- Both databases failed during the polling interval. Specifically, the Operator examined both databases and the TimesTen Pods were in the `Healthy` state. The Operator waited `pollingInterval` seconds, and when the Operator examined the databases again (after this `pollingInterval`), both databases were down **and**
- `RETURN TWOSAFE` replication was configured **and**
- `DISABLE RETURN` or `LOCAL COMMIT ACTION COMMIT` (or both) were configured.

See TimesTenClassicSpecSpec for more information on the `.spec.ttspec.pollingInterval` datum and on the `RETURN TWOSAFE` and `DISABLE RETURN` replication configurations options. For information about defining an active standby pair replication scheme, see CREATE ACTIVE STANDBY PAIR in the *Oracle TimesTen In-Memory Database SQL Reference* and Defining an Active Standby Pair Replication Scheme in the *Oracle TimesTen In-Memory Database Replication Guide*

This combination of events indicates that some transactions may have committed on the standby and not on the active and/or some transactions may have committed on the active and not on the standby. The TimesTen Operator takes no action in this case.

When both databases fail, the TimesTenClassic object enters the BothDown state. The Operator must then determine the appropriate action to take. The Operator first examines the value of the `.spec.ttspec.bothDownBehavior` datum to determine what to do.

If `.spec.ttspec.bothDownBehavior` is set to `Manual`, the TimesTenClassic object immediately enters the `ManualInterventionRequired` state. The Operator takes no further action even if either TimesTen container subsequently becomes available. See About the ManualInterventionRequired State for Replicated Objects.

If `.spec.ttspec.bothDownBehavior` is set to `Best` (the default setting), the Operator attempts to determine which database was ahead at the time of failure.

- If the Operator cannot determine which database is ahead, the TimesTenClassic object immediately enters the `ManualInterventionRequired` state. See About the ManualInterventionRequired State for Replicated Objects.
- If the Operator can determine which database is ahead:
  - The TimesTenClassic object enters the `WaitingForActive` state. The object remains in this state until the Pod containing that database is running and the TimesTen agent located in the `tt` container within that Pod is responding to the Operator. At this point, the TimesTenClassic object enters the `ConfiguringActive` state.
  - While the TimesTenClassic object is in the `ConfiguringActive` state, TimesTen in this Pod is started, the database is loaded and is configured for use as the new active database. If there are any problems with these steps, the TimesTenClassic object enters the `ManualInterventionRequired` state. If the database is successfully loaded and successfully configured as the new active, the TimesTenClassic object enters the `StandbyDown` state. See About the High Level State of TimesTenClassic Objects for information on the states of your TimesTenClassic object.
  - You can specify the maximum amount of time (expressed in seconds) that the TimesTenClassic object remains in the `WaitingForActive` state by specifying a value for the `spec.ttspec.waitingForActiveTimeout` datum. After this period of time, if the object is still in the `WaitingForActive` state, the object automatically transitions to the `ManualInterventionRequired` state. The default is `0`, which indicates that there is no timeout, and the object will remain in this state indefinitely. See TimesTenClassicSpecSpec for more information on the `spec.ttspec.waitingForActiveTimeout` datum.

- The time to recover the database varies by the size of the database. You should consider the size of your database when deciding the value for `spec.ttspec.waitingForActiveTimeout`.
- If the database that is ahead cannot be loaded, the TimesTenClassic object enters the `ManualInterventionRequired` state. See About the ManualInterventionRequired State for Replicated Objects.

About the ManualInterventionRequired State for Replicated Objects

When a replicated TimesTenClassic object enters the `ManualInterventionRequired` state, the TimesTen Operator takes no further action for this object. It does not query the TimesTen agents associated with the object to determine the state of TimesTen and does not command TimesTen to do anything. It is important for you to address why the TimesTenClassic object is in this state.

If your TimesTenClassic object is in the `ManualInterventionRequired` state and it is not the result of it first being in the `BothDown` state, perform the operations necessary to manually repair one of the databases. Then, perform the steps to bring up this database. These steps are covered in About Bringing Up One Database later in this chapter.

If, however, the TimesTenClassic object is in the `ManualInterventionRequired` state as a result of it first being in the `BothDown` state:

- It may be unclear which database, if either, is suitable to be the new active. There may be transactions that have committed on the active database and not on the standby database, and simultaneously there may be transactions that have committed on the standby database and not on the active database.
- You need to manually examine both databases and may need to reconcile the data before you can choose which database should be the new active.
- If you can reconcile the data, and can manually fix one of the databases, then you can perform the steps to bring up one database. These steps are covered in About Bringing Up One Database later in this chapter. If you cannot reconcile the data, contact Oracle Support for further assistance.

In order for you to direct the Operator to move the TimesTenClassic object out of the `ManualInterventionRequired` state, you must either:

- Bring up exactly one database: The Operator treats this database as the active database. All of these conditions must be met:
  - The TimesTen agent in the container is running.
  - The TimesTen the instance in the container is running.
  - The TimesTen database is loaded.
  - There is no replication scheme in the database.
  - The replication agent is not running.
  - The replication state is `IDLE`.

  If these conditions are met, the Operator moves the TimesTenClassic object to the `StandbyDown` state. If any of these conditions are not met, the TimesTenClassic object remains in the `ManualInterventionRequired` state. Note that when no replication scheme exists in the database, the Operator will still create the appropriate replication scheme based on how it is defined in the TimesTenClassic object definition. See About Bringing Up

One Database for an example of how you can direct the Operator to take action once one database is up and running.

- Bring up both databases: In this case, you must configure the active standby pair. Specifically, each database must meet all of the following conditions:
  - The TimesTen agent in the container is running.
  - The TimesTen instance in the container is running.
  - The database is loaded.
  - The replication scheme is defined in both databases.
  - The replication agents are started and are running.
  - One database must be in the `ACTIVE` state and the other database must be in the `STANDBY` state.

  If these conditions are met, the Operator moves the TimesTenClassic object to the `Normal` state. If any of these conditions are not met, the TimesTenClassic object remains in the `ManualInterventionRequired` state.

If you cannot bring up either database, the TimesTenClassic object remains in the `ManualInterventionRequired` state.

You direct the Operator to examine the databases by specifying the `.spec.ttspec.reexamine` datum. Every `.spec.ttspec.pollingInterval`, the Operator examines the value of `.spec.ttspec.reexamine`. If the value has changed since the last iteration for this TimesTenClassic object, the Operator examines the state of the TimesTen containers for this object. See TimesTenClassicSpecSpec for more information on the `.spec.ttspec.pollingInterval` and the `.spec.ttspec.reexamine` datum.

The examination of the databases is performed exactly one time after you change the `.spec.ttspec.reexamine` value. If the required conditions were not met, you may again attempt to meet them. You must then modify the `.spec.ttspec.reexamine` value again to cause the Operator to reexamine the databases.

Note that whenever a TimesTenClassic object changes state, a Kubernetes Event is created. You can monitor these events with the `kubectl describe` command to be informed of such state transitions.

About Bringing Up One Database

This section assumes you have manually repaired or have manually performed maintenance on one of the databases associated with a replicated TimesTenClassic object. The TimesTenClassic object is currently in the `ManualInterventionRequired` state. You now want to direct the TimesTen Operator to treat the repaired database as the active, to perform the necessary steps to duplicate this database to the standby, and to bring up both databases, such that both are running and operating successfully.

Recall that all of these conditions must be met for the database:

- TimesTen agent in the container is running.
- TimesTen daemon (the instance) in the container is running.
- TimesTen database is loaded.
- There is no replication scheme in the database.
- The replication agent is not running.
- The replication state is `IDLE`.

These sections show you how to verify the conditions are met for the database and how to set the `reexamine` value:

- Verify Conditions Are Met for the Database
- Set the reexamine Value

Verify Conditions Are Met for the Database

Perform these steps to ensure the conditions are met for the database (the database to be the active). In this example, `sample-1` will be the new active.

Note: These steps require you to use TimesTen utilities and TimesTen built-in procedures. See Utilities and Built-In Procedures in the *Oracle TimesTen In-Memory Database Reference* for details.

1. Confirm the TimesTenClassic object (`sample`, in this example) is in the `ManualInterventionRequired` state (represented in **bold**).

   ```
   % kubectl get ttc sample
   NAME     STATE                        ACTIVE     AGE
   sample   ManualInterventionRequired   sample-0   12h
   ```

2. Use the `kubectl exec -it` command to invoke the shell within the `sample-1` Pod that contains the TimesTen database. (This database will be the new active.)

   The remaining procedures take place within this shell.

   ```
   % kubectl exec -it sample-1  -c tt -- /bin/bash
   ```

3. Use the `ttDaemonAdmin` utility to start TimesTen daemon (if not already started). Then use the `ttAdmin` utility to load the TimesTen database into memory (if not already loaded).

   ```
   % ttDaemonAdmin -start
   TimesTen Daemon (PID: 5948, port: 6624) startup OK.
   % ttAdmin -ramLoad sample
   RAM Residence Policy            : manual
   Manually Loaded In RAM          : True
   Replication Agent Policy        : manual
   Replication Manually Started    : False
   Cache Agent Policy              : manual
   Cache Agent Manually Started    : False
   Database State                  : Open
   ```

4. Use the `ttIsql` utility to connect to the `sample` database. Then, call the `ttRepStop` built-in procedure to stop the replication agent.

   ```
   % ttIsql sample

   Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
   Type ? or "help" for help, type "exit" to quit ttIsql.



   connect "DSN=sample";
   Connection successful: DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/
   sample;
   DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;AutoCreate=0;
   PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled=1;
   (Default setting AutoCommit=1)
   Command> call ttRepStop;
   ```

5. From within `ttIsql`, use the SQL `DROP ACTIVE STANDBY PAIR` statement to drop the active standby pair replication scheme. Then use the `ttIsql` `repschemes` command to verify there are no replication schemes in the database. Exit from `ttIsql`.

```
Command> DROP ACTIVE STANDBY PAIR;
Command> repschemes;

0 replication schemes found.
```

6. Use the `ttStatus` utility to verify the TimesTen daemon is running and the replication agent is not running. Note: The `ttStatus` output may change from release to release.

```
% ttStatus
TimesTen status report as of Thu Jan 16 02:14:15 2025

Daemon pid 5948 port 6624 instance instance1
TimesTen server pid 5955 started on port 6625
------------------------------------------------------------------------
------------------------------------------------------------------------
Data store /tt/home/timesten/datastore/sample
Daemon pid 5948 port 6624 instance instance1
TimesTen server pid 5955 started on port 6625
There are 15 connections to the data store
Shared Memory KEY 0x0a100c60 ID 196609
PL/SQL Memory Key 0x0b100c60 ID 229378 Address 0x5000000000
Type            PID     Context             Connection Name              ConnID
Process         10418   0x000000000218a6e0  sample                            2
Process         8338    0x0000000001cbb6e0  sample                            1
Subdaemon       5953    0x00000000015075f0  Manager                        2047
Subdaemon       5953    0x0000000001588540  Rollback                       2046
Subdaemon       5953    0x0000000001607210  Checkpoint                     2041
Subdaemon       5953    0x00007f132c0008c0  Flusher                        2045
Subdaemon       5953    0x00007f132c080370  Log Marker                     2040
Subdaemon       5953    0x00007f13340008c0  Monitor                        2044
Subdaemon       5953    0x00007f133407f330  HistGC                         2037
Subdaemon       5953    0x00007f13380008c0  Aging                          2042
Subdaemon       5953    0x00007f133807f330  AsyncMV                        2039
Subdaemon       5953    0x00007f133c0008c0  Deadlock Detector              2043
Subdaemon       5953    0x00007f133c07f330  IndexGC                        2038
Subdaemon       5953    0x00007f135c0008c0  Garbage Collector              2035
Subdaemon       5953    0x00007f13600e8e20  XactId Rollback                2036
Open for user connections
RAM residence policy: Manual
Data store is manually loaded into RAM
Replication policy  : Manual
Cache Agent policy  : Manual
PL/SQL enabled.
------------------------------------------------------------------------
Accessible by group timesten
End of report
```

You successfully verified the conditions for the database. The database is up and running. The Operator will treat this database as the active. You are now ready to set the value for the `.spec.ttspec.reexamine` datum.

Set the reexamine Value

This example shows you how to set the `reexamine` value for a replicated TimesTenClassic object. The example also illustrates the action the TimesTen Operator takes after the `reexamine` value has been changed.

1. Set the `reexamine` value. The value must be different than the current value for the TimesTenClassic object. When the TimesTen Operator examines this value and notices it has changed since the last iteration, it takes appropriate action.

   Use the `kubectl edit` command to edit the TimesTenClassic object.

   - If there is a line for `reexamine` in the file, then modify its value. It must be different than the current value.
   - If there is no line for `reexamine` in the file, then add a line and specify a value.

   In this example, there is no `reexamine` line. This example adds the `reexamine` line and sets the value for `reexamine` to `April22reexamine1` (represented in **bold**).

   Note: Not all output is shown.

```
% kubectl edit timestenclassic sample
# Please edit the object below. Lines beginning with a '#' will be ignored,
# and an empty file will abort the edit. If an error occurs while saving this
# file will be reopened with the relevant failures.
#
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
...
  name: sample
  namespace: mynamespace
...
repCreateStatement: |
  create active standby pair
    "{{tt-name}}" on "{{tt-node-0}}",
    "{{tt-name}}" on "{{tt-node-1}}"
  RETURN TWOSAFE
  store "{{tt-name}}" on "{{tt-node-0}}"
    PORT {{tt-rep-port}} FAILTHRESHOLD 0 TIMEOUT 999
  store "{{tt-name}}" on "{{tt-node-1}}"
    PORT {{tt-rep-port}} FAILTHRESHOLD 0 TIMEOUT 999
spec:
  ttspec:
    bothDownBehavior: Best
    dbConfigMap:
    - sample
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    storageClassName: oci-bv
    storageSize: 250Gi
    reexamine: April22reexamine1
...
timestenclassic.timesten.oracle.com/sample edited
```

2. Use the `kubectl get` command to assess the state of the `sample` TimesTenClassic object. Observe how the state changes as you issue multiple `kubectl get` commands. Also note that the Operator has successfully configured `sample-1` to be the active.

```
% kubectl get ttc sample
NAME     STATE       ACTIVE   AGE
sample   Reexamine   None     68m
% kubectl get ttc sample
NAME     STATE               ACTIVE   AGE
sample   ConfiguringActive   None     68m
% kubectl get ttc sample
NAME     STATE         ACTIVE     AGE
sample   StandbyDown   sample-1   68m
% kubectl get ttc sample
```

```
NAME     STATE    ACTIVE     AGE
sample   Normal   sample-1   71m
```

3. Use the `kubectl describe` command to further review the actions of the Operator (represented in **bold**).

   Not all output is shown:

```
% kubectl describe ttc sample
Name:         sample
Namespace:    mynamespace
...
Kind:         TimesTenClassic
...
Rep Create Statement:  create active standby pair
  "{{tt-name}}" on "{{tt-node-0}}",
  "{{tt-name}}" on "{{tt-node-1}}"
RETURN TWOSAFE
store "{{tt-name}}" on "{{tt-node-0}}"
  PORT {{tt-rep-port}} FAILTHRESHOLD 0 TIMEOUT 999
store "{{tt-name}}" on "{{tt-node-1}}"
  PORT {{tt-rep-port}} FAILTHRESHOLD 0 TIMEOUT 999

Spec:
  Ttspec:
    Both Down Behavior:  Best
    Db Config Map:
      sample
    Image:               container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    Image Pull Policy:   Always
    Image Pull Secret:   sekret
    Reexamine:           April22reexamine1
    Stop Managing:       April21Stop1
    Storage Class Name:  oci-bv
    Storage Size:        250Gi
Status:
  Classic Upgrade Status:
    Active Start Time:           0
    Active Status:
    Image Update Pending:        false
    Last Upgrade State Switch:   0
    Prev Reset Upgrade State:
    Prev Upgrade State:
    Standby Start Time:          0
    Standby Status:
    Upgrade Start Time:          0
    Upgrade State:
  Active Pods:                   sample-1
  High Level State:              Normal
  Last Event:                    54
  Last High Level State Switch:  1619230912
  Pod Status:
    Cache Status:
      Cache Agent:        Not Running
      Cache UID Pwd Set:  true
      N Cache Groups:     0
    Db Status:
      Db:                          Loaded
      Db Id:                       475
      Db Updatable:                No
    Initialized:                   true
    Last High Level State Switch:  ?
    Pod Status:
```

```
  Agent:                Up
  Last Time Reachable:  1619231126
  Pod IP:               10.244.7.89
  Pod Phase:            Running
Prev High Level State:  Healthy
Prev Image:
Replication Status:
  Last Time Rep State Changed:  0
  Rep Agent:                    Running
  Rep Peer P State:             start
  Rep Scheme:                   Exists
  Rep State:                    STANDBY
Times Ten Status:
  Daemon:          Up
  Instance:        Exists
  Release:         26.1.1.1.0
Admin User File:   false
Cache User File:   false
Cg File:           false
Disable Return:    false
High Level State:  Healthy
Intended State:    Standby
Local Commit:      false
Name:              sample-0
Schema File:       false
Using Twosafe:     false
Cache Status:
  Cache Agent:        Not Running
  Cache UID Pwd Set:  true
  N Cache Groups:     0
Db Status:
  Db:                          Loaded
  Db Id:                       476
  Db Updatable:                Yes
Initialized:                   true
Last High Level State Switch:  ?
Pod Status:
  Agent:                Up
  Last Time Reachable:  1619231126
  Pod IP:               10.244.6.149
  Pod Phase:            Running
Prev High Level State:  Healthy
Prev Image:
Replication Status:
  Last Time Rep State Changed:  1619228670
  Rep Agent:                    Running
  Rep Peer P State:             start
  Rep Scheme:                   Exists
  Rep State:                    ACTIVE
Times Ten Status:
  Daemon:             Up
  Instance:           Exists
  Release:            26.1.1.1.0
Admin User File:      false
Cache User File:      false
Cg File:              false
Disable Return:       false
High Level State:     Healthy
Intended State:       Active
Local Commit:         false
Name:                 sample-1
Schema File:          false
```

```
    Using Twosafe:        false
  Prev High Level State:  StandbyDown
  Prev Reexamine:         April22reexamine1
  Prev Stop Managing:     April21Stop1
  Rep Create Statement:   create active standby pair "sample" on
"sample-0.sample.mynamespace.svc.cluster.local", "sample" on
"sample-1.sample.mynamespace.svc.cluster.local" NO RETURN store "sample" on
"sample-0.sample.mynamespace.svc.cluster.local" PORT 4444 FAILTHRESHOLD 0 store
"sample" on "sample-1.sample.mynamespace.svc.cluster.local" PORT 4444 FAILTHRESHOLD 0
  Rep Port:               4444
  Status Version:         1.0
Events:
  Type  Reason       Age    From       Message
  ----  ------       ----   ----       -------
  -     StateChange  58m    ttclassic  TimesTenClassic was Normal, now
ManualInterventionRequired
  -     StateChange  46m    ttclassic  Pod sample-0 Daemon Down
  -     StateChange  41m    ttclassic  Pod sample-1 Daemon Down
  -     StateChange  41m    ttclassic  Pod sample-1 Daemon Up
  -     StateChange  41m    ttclassic  Pod sample-1 Database Unloaded
  -     StateChange  40m    ttclassic  Pod sample-1 Database Loaded
  -     StateChange  40m    ttclassic  Pod sample-1 RepState IDLE
  -     StateChange  40m    ttclassic  Pod sample-1 RepAgent Not Running
  -     StateChange  17m    ttclassic  Pod sample-1 Database Updatable
  -     StateChange  17m    ttclassic  Pod sample-1 RepScheme None
  -     StateChange  4m21s  ttclassic  TimesTenClassic was
ManualInterventionRequired, now Reexamine
  -     Error        4m16s  ttclassic  Active error: Daemon Down
  -     StateChange  4m16s  ttclassic  TimesTenClassic was Reexamine, now
ConfiguringActive
  -     StateChange  4m10s  ttclassic  Pod sample-1 RepState ACTIVE
  -     StateChange  4m10s  ttclassic  Pod sample-1 RepScheme Exists
  -     StateChange  4m10s  ttclassic  Pod sample-1 RepAgent Running
  -     StateChange  4m8s   ttclassic  TimesTenClassic was ConfiguringActive, now
StandbyDown
  -     StateChange  4m3s   ttclassic  Pod sample-0 Daemon Up
  -     StateChange  4m3s   ttclassic  Pod sample-0 Database Unloaded
  -     StateChange  3m56s  ttclassic  Pod sample-0 Database None
  -     StateChange  3m42s  ttclassic  Pod sample-0 Database Loaded
  -     StateChange  3m42s  ttclassic  Pod sample-0 Database Not Updatable
  -     StateChange  3m42s  ttclassic  Pod sample-0 RepAgent Not Running
  -     StateChange  3m42s  ttclassic  Pod sample-0 RepState IDLE
  -     StateChange  3m36s  ttclassic  Pod sample-0 RepAgent Running
  -     StateChange  3m36s  ttclassic  Pod sample-0 RepState STANDBY
  -     StateChange  3m36s  ttclassic  TimesTenClassic was StandbyDown, now Normal
```

4. Use the `kubectl exec -it` command to invoke the shell within the `sample-1` Pod that contains the TimesTen database. Then, verify you can connect to the active database.

```
% kubectl exec -it sample-1 -c tt -- /bin/bash
$ ttIsql sample

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Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful: DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/
sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;AutoCreate=0;PermSize=2
00;DDLReplicationLevel=3;ForceDisconnectEnabled=1;
(Default setting AutoCommit=1)
```

```
Command> call ttRepStateGet;
< ACTIVE >
1 row found.
```

5. Use the `kubectl exec -it` command to invoke the shell within the `sample-0` Pod that contains the TimesTen database. Then, verify you can connect to the standby database.

```
% kubectl exec -it sample-0 -c tt -- /bin/bash
% ttIsql sample

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Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful: DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/
sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;AutoCreate=0;
PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled=1;
(Default setting AutoCommit=1)
Command> call ttRepStateGet;
< STANDBY >
1 row found.
```

The TimesTen Operator is now managing and monitoring your TimesTenClassic object. The TimesTenClassic object is in the `Normal` state. Both databases are up and running and ready for use.

About Suspending Management of a TimesTenClassic Object

The TimesTen Operator examines the state of the TimesTen instances and the databases associated with each TimesTenClassic object. It takes actions to repair anything that is broken. You may have a situation in which you want to manually perform maintenance operations. In such a situation, you do not want the TimesTen Operator to interfere and attempt to perform repair operations.

You could stop the TimesTen Operator by deleting the `timesten-operator` Deployment. This action prevents the Operator from interfering. See Revert to Manual Control. However, if you have more than one TimesTenClassic object and you delete the TimesTen Operator, this interferes with the management of all the TimesTenClassic objects, when perhaps only one of them needs manual intervention.

You can direct the TimesTen Operator to take no action for one or more TimesTenClassic objects by specifying the `.spec.ttspec.stopManaging` datum in the TimesTenClassic object's definition. The TimesTen Operator examines the value of `.spec.ttspec.stopManaging` and if it has changed since the last time the Operator examined it, the Operator changes the state of the TimesTenClassic object to `ManualInterventionRequired`. This causes the Operator to no longer examine the status of the TimesTen Pods, the containers, the instances, and the databases associated with the TimesTenClassic object. The Operator takes no action on the object or its Pods.

When you want the TimesTen Operator to manage the TimesTenClassic object again, you use the `.spec.ttspec.reexamine` datum. These actions enable you to perform manual operations on TimesTen without deleting the TimesTen Operator.

For an example, see Suspend Management.

Suspend Management

You can instruct the TimesTen Operator to stop managing one or more TimesTenClassic objects that are running in your namespace. To do so, use the TimesTenClassic object's `.spec.ttspec.stopManaging` datum.

Let's look at an example.

1. Review the TimesTenClassic objects that are running in your namespace.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME            STATE              ACTIVE          AGE
   samplenorep     AllReplicasReady   N/A             47h
   samplerep       Normal             samplerep-0     2d
   ```

   There are two TimesTenClassic objects. The `samplenorep` is a non-replicated object and all replicas are ready. The `samplerep` is a replicated object that is in the `Normal` state.

2. Review the Pods.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                 READY   STATUS    RESTARTS   AGE
   samplenorep-0                        3/3     Running   0          47h
   samplenorep-1                        3/3     Running   0          47h
   samplenorep-2                        3/3     Running   0          47h
   samplerep-0                          3/3     Running   0          2d
   samplerep-1                          2/3     Running   0          2d
   timesten-operator-6b9b7f8fb4-vvl69   1/1     Running   0          2d1h
   ```

   For the `samplenorep` non-replicated object, there are three Pods running representing three databases (`replicas=3`). For the `samplerep` replicated object, there are two Pods running. One Pod represents the active database (`samplerep-0`) and one Pod represents the standby database (`samplerep-1`).

3. Instruct the TimesTen Operator to stop managing the `samplenorep` object.

   a. Use the `kubectl edit` command to edit the object.

      If there is a line for `.spec.ttspec.stopManaging` in the file, then modify its value. It must be different than the current value. If there is no line, add a line and specify a value.

      This example adds the `.spec.ttspec.stopManaging` datum and sets the value to `stopManagingNow`.

      ```
      kubectl edit ttc samplenorep

      # Please edit the object below. Lines beginning with a '#' will be
      ignored,
      ```

```
# and an empty file will abort the edit. If an error occurs while
saving this file will be
# reopened with the relevant failures.
#
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
...
spec:
  ttspec:
    additionalMemoryRequest: 2Gi
    automaticMemoryRequests: true
    cacheCleanup: true
    createASReadinessProbe: true
    daemonLogCPURequest: 200m
    daemonLogMemoryRequest: 200Mi
    stopManaging: stopManagingNow
...
```

   b. Save and close the file.

4. Confirm the `samplenorep` object is in the `ManualInterventionRequired` state.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME            STATE                        ACTIVE         AGE
   samplenorep     ManualInterventionRequired   N/A            2d
   samplerep       Normal                       samplerep-0    2d1h
   ```

   The TimesTen Operator moved the `samplenorep` object to the `ManualInterventionRequired` state.

5. Confirm the TimesTen Operator moved each of the Pods for the `samplenorep` object to the `ManualInterventionRequired` state.

   ```
   kubectl get events
   ```

   The output is similar to the following. Not all output is displayed.

   ```
   LAST SEEN   TYPE      REASON        OBJECT
   MESSAGE
   11m         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-0 state was Normal, now ManualInterventionRequired
   11m         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-1 state was Normal, now ManualInterventionRequired
   11m         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-2 state was Normal, now ManualInterventionRequired
   11m         Normal    StateChange   timestenclassic/samplenorep
   TimesTenClassic was AllReplicasReady, now ManualInterventionRequired
   ```

   The TimesTen Operator successfully moved the Pods to the `ManualInterventionRequired` state.

6. Instruct the TimesTen Operator to stop managing the `samplenorep` object.

   a. Use the `kubectl edit` command to edit the object.

      If there is a line for `.spec.ttspec.stopManaging` in the file, then modify its value. It must be different than the current value. If there is no line, add a line and specify a value.

      This example adds the `.spec.ttspec.stopManaging` datum and sets the value to `stopManagingNow`.

      ```
      kubectl edit ttc samplerep

      # Please edit the object below. Lines beginning with a '#' will be
      ignored,
      # and an empty file will abort the edit. If an error occurs while
      saving this file will be
      # reopened with the relevant failures.
      #
      apiVersion: timesten.oracle.com/v4
      kind: TimesTenClassic
      metadata:
      ...
      spec:
        ttspec:
          additionalMemoryRequest: 2Gi
          automaticMemoryRequests: true
          cacheCleanup: true
          createASReadinessProbe: true
          daemonLogCPURequest: 200m
          daemonLogMemoryRequest: 200Mi
          stopManaging: stopManagingNow
      ...
      ```

   b. Save and close the file.

7. Confirm the `samplerep` object is in the `ManualInterventionRequired` state.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME           STATE                        ACTIVE          AGE
   samplenorep    ManualInterventionRequired   N/A             2d
   samplerep      ManualInterventionRequired   samplerep-0     2d1h
   ```

   The TimesTen Operator moved the `samplerep` object to the `ManualInterventionRequired` state.

You successfully instructed the TimesTen Operator to move TimesTenClassic objects to the `ManualInterventionRequired` state. The TimesTen Operator is no longer monitoring or managing the objects. It takes no further action on the objects or its Pods. You can now perform manual operations on your TimesTen databases. When you are ready for the TimesTen Operator to resume management of one or both objects, do the following:

- For non-replicated objects, such as `samplenorep`, proceed to Resume Management.
- For replicated objects, such as `samplerep`, proceed to About Bringing Up One Database.

Resume Management

If a TimesTenClassic object is in the `ManualInterventionRequired` state, you can instruct the TimesTen Operator to examine the state of TimesTen and its databases to see if they are healthy. For the procedures for replicated objects, proceed to About Bringing Up One Database.

For non-replicated objects, set the object's `.spec.ttspec.reexamine` datum. Doing so instructs the TimesTen Operator to move the object to the `Reexamine` state. In the `Reexamine` state, the TimesTen Operator examines the state of TimesTen and its databases. If healthy, the Operator returns the object to the `AllReplicasReady` state. If not healthy, the object re-enters the `ManualInterventionRequired` state.

1. Review the TimesTenClassic objects that are running in your namespace.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME             STATE                        ACTIVE           AGE
   samplenorep      ManualInterventionRequired   N/A              2d1h
   ...
   ```

   The replicated `samplenorep` object is in the `ManualInterventionRequired` state.

2. Instruct the TimesTen Operator to resume management of the `samplenorep` object.

   a. Use the `kubectl edit` command to edit the object.

      If there is a line for `.spec.ttspec.reexamine` in the file, then modify its value. It must be different than the current value. If there is no line, add a line and specify a value.

      This example adds the `.spec.ttspec.reexamine` datum and sets the value to `reexamineNow`.

      ```
      kubectl edit ttc samplenorep

      # Please edit the object below. Lines beginning with a '#' will be
      ignored,
      # and an empty file will abort the edit. If an error occurs while
      saving this file will be
      # reopened with the relevant failures.
      #
      apiVersion: timesten.oracle.com/v4
      kind: TimesTenClassic
      metadata:
      ...
      spec:
        ttspec:
          additionalMemoryRequest: 2Gi
          automaticMemoryRequests: true
          cacheCleanup: true
          createASReadinessProbe: true
          daemonLogCPURequest: 200m
          daemonLogMemoryRequest: 200Mi
      ```

```
       reexamine: rexamineNow
    ...
```

   b. Save and close the file.

3. Observe the behavior.

   ```
   kubectl get events
   ```

   The output is similar to the following. Not all output is displayed.

   ```
   27s         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-0 state was ManualInterventionRequired, now Reexamine
   27s         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-1 state was ManualInterventionRequired, now Reexamine
   27s         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-2 state was ManualInterventionRequired, now Reexamine
   27s         Normal    StateChange   timestenclassic/samplenorep
   TimesTenClassic was ManualInterventionRequired, now Reexamine
   22s         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-0 state was Reexamine, now Normal
   22s         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-1 state was Reexamine, now Normal
   22s         Normal    StateChange   timestenclassic/samplenorep      Pod
   samplenorep-2 state was Reexamine, now Normal
   22s         Normal    StateChange   timestenclassic/samplenorep
   TimesTenClassic was Reexamine, now AllReplicasReady
   ```

   The TimesTen Operator changed the state of each TimesTen Pod from `ManualInterventionRequired` to `Reexamine` and changed the TimesTenClassic object's state from `ManualInterventionRequired` to `Reexamine`. The TimesTen Operator examined TimesTen and its databases. Since TimesTen and its databases are healthy and functioning properly, the TimesTen Operator changed the state of the TimesTen Pods to `Normal` and the state of the TimesTenClassic object to `AllReplicasReady`.

About Manual Operations

The TimesTen Operator strives to keep TimesTen databases running once they are deployed. Kubernetes manages the lifecycle of the Pods. It recreates the Pods if they fail. If the nodes on which the Pods are running fail, Kubernetes recreates the Pods on available Kubernetes cluster nodes. The TimesTen Operator monitors TimesTen running in the Pods and initiates the appropriate operations to keep the databases operational. The TimesTen Operator performs these operations automatically and there is minimal human intervention required.

If necessary, there are the manual operations you can perform:

- Manually Invoke TimesTen Utilities
- Revert to Manual Control
- Delete TimesTen Databases
- Locate the TimesTen Operator
- Modify TimesTen Connection Attributes

Manually Invoke TimesTen Utilities

You can manually invoke TimesTen utilities on TimesTen instances. Use the `kubectl exec -it` command to invoke a shell in a container in a TimesTen Pod. Once in the container, you can invoke TimesTen utilities and perform additioanal operations.

Note

The TimesTen Operator continues to query the status of the Pod and the status of TimesTen within the Pod. If you invoke a command that disrupts the functioning of either the Pod or TimesTen, the Operator may act to try to fix what you did.

This example shows how to use the `kubectl exec -it` command to invoke a shell within the `sample-0` Pod that contains the active TimesTen database in an active standby pair configuration. The example then runs the `ttIsql` utility.

```
% kubectl exec -it sample-0 -c tt -- /bin/bash
% ttIsql sample

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Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful:
DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;PermSize=200;
DDLReplicationLevel=3;
(Default setting AutoCommit=1)
```

Revert to Manual Control

If you want to manually operate and control TimesTen databases, you can delete the `timesten-operator` Deployment. This causes the TimesTen Operator to stop. It does not restart. This affects all of the TimesTenClassic objects that are running in your Kubernetes namespace. If you do not want the TimesTen Operator to stop managing all of the TimesTenClassic objects, you can suspend the management of individual TimesTenClassic objects. See About Suspending Management of a TimesTenClassic Object.

A TimesTenClassic object remains in Kubernetes as do other Kubernetes objects associated with the TimesTenClassic object. You can use the `kubectl exec -it` command to invoke a shell in one or more Pods and you can control Timesten running in those Pods.

If a Pod fails, Kubernetes creates new ones to replace them. This is due to the StatefulSet object that the TimesTen Operator had previously created in Kubernetes. However, since the TimesTen Operator is not running the new Pods, it cannot automatically start TimesTen. In this case, your TimesTen databases cannot be configured or started. You are responsible for the operation of TimesTen in the Pods.

If you want the TimesTen Operator to take control, you must redeploy the Operator. Once the Operator is redeployed, it automatically identifies the TimesTenClassic objects in your Kubernetes cluster and attempts to manage them again.

This example shows you how to manually control TimesTen.

1. Verify the Operator and the TimesTen databases are running.

```
% kubectl get pods
NAME                                        READY   STATUS    RESTARTS   AGE
sample-0                                    3/3     Running   0          18h
sample-1                                    2/3     Running   0          18h
timesten-operator-5d7dcc7948-pzj58          1/1     Running   0          18h
```

2. Navigate to the `/deploy` directory where the `operator.yaml` resides. (`*kube_files*/deploy`, in this example.)

```
% cd kube_files/deploy
```

3. Use the `kubectl delete` command to delete the Operator. The Operator is stopped and no longer deployed.

```
% kubectl delete -f operator.yaml
deployment.apps "timesten-operator" deleted
```

4. Verify the Operator is no longer running, but the TimesTen databases are.

```
% kubectl get pods
NAME       READY   STATUS    RESTARTS   AGE
sample-0   3/3     Running   0          19h
sample-1   2/3     Running   0          19h
```

5. Use the `kubectl exec -it` command to invoke a shell in a Pod that runs TimesTen.

```
% kubectl exec -it sample-0 -c tt -- /bin/bash
Last login: Thu Jan  16 14:30:45 UTC 2025 on pts/0
```

6. Run the `ttStatus` utility.

```
% ttStatus
TimesTen status report as of Thu Jan  16 14:36:31 2025

Daemon pid 183 port 6624 instance instance1
TimesTen server pid 190 started on port 6625
------------------------------------------------------------------------
------------------------------------------------------------------------
Data store /tt/home/timesten/datastore/sample
Daemon pid 183 port 6624 instance instance1
TimesTen server pid 190 started on port 6625
There are 20 connections to the data store
Shared Memory KEY 0x02200bbc ID 32769
PL/SQL Memory Key 0x03200bbc ID 65538 Address 0x5000000000
Type            PID     Context            Connection Name              ConnID
Replication     263     0x00007f99fc0008c0 LOGFORCE:140299698493184      2029
Replication     263     0x00007f9a040008c0 XLA_PARENT:140300350273280    2031
Replication     263     0x00007f9a080008c0 REPLISTENER:140300347123456   2030
Replication     263     0x00007f9a080acd60 RECEIVER:140299429472000      2028
Replication     263     0x00007f9a0c0008c0 FAILOVER:140300353423104      2032
Replication     263     0x00007f9a2c0009b0 TRANSMITTER(M):140299695343360 2034
Replication     263     0x00007f9a300008c0 REPHOLD:140300356572928       2033
Subdaemon       187     0x00000000023365b0 Manager                        2047
Subdaemon       187     0x00000000023b57f0 Rollback                       2046
Subdaemon       187     0x0000000002432cf0 Log Marker                     2041
Subdaemon       187     0x000000000244fc00 Garbage Collector              2035
Subdaemon       187     0x00007f90c80008c0 Aging                          2038
Subdaemon       187     0x00007f90d00008c0 Deadlock Detector              2044
Subdaemon       187     0x00007f90d001d7d0 HistGC                         2039
Subdaemon       187     0x00007f90d40008c0 Checkpoint                     2042
Subdaemon       187     0x00007f90d401d7d0 AsyncMV                        2036
Subdaemon       187     0x00007f90d80008c0 Monitor                        2043
Subdaemon       187     0x00007f90f808b360 IndexGC                        2037
Subdaemon       187     0x00007f90fc0008c0 Flusher                  2045
Subdaemon       187     0x00007f910004efd0 XactId Rollback          2040
Open for user connections
RAM residence policy: Always
Replication policy  : Manual
Replication agent is running.
Cache Agent policy  : Manual
PL/SQL enabled.
------------------------------------------------------------------------
Accessible by group timesten
End of report
```

7. Run the `ttIsql` utility to connect to the `sample` database and perform various operations.

```
% ttIsql sample

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Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful:
DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;PermSize=200;
DDLReplicationLevel=3;
(Default setting AutoCommit=1)
Command> describe sampleuser.emp;

Table SAMPLEUSER.EMP:
  Columns:
   *ID                             NUMBER NOT NULL
    NAME                           CHAR (32)

1 table found.
(primary key columns are indicated with *)

Command> INSERT INTO sampleuser.emp VALUES (1,'This is a test.');
1 row inserted.
Command> SELECT * FROM sampleuser.emp;
< 1, This is a test.                  >
1 row found.
```

Delete TimesTen Databases

If you delete a TimesTenClassic object, Kubernetes automatically deletes all of the Kubernetes objects and the resources it is using, including the StatefulSet, Service, and Pods. However, Kubernetes does not delete the PersistentVolumeClaims that contain the TimesTen databases. After you delete a TimesTenClassic object, you must manually delete the PersistentVolumeClaims (PVCs) associated with the object. After you manually delete the PVCs, Kubernetes recycles PersistentVolumes that are holding the databases. You may be able to control the recycling operation by using a Kubernetes volume retention policy. However, the TimesTen Operator has no control over this process.

The following example deletes PVCs associated with a replicated TimesTenClassic object called `sample`.

```
% kubectl delete pvc tt-persistent-sample-0
persistentvolumeclaim "tt-persistent-sample-0" deleted
% kubectl delete pvc tt-persistent-sample-1
persistentvolumeclaim "tt-persistent-sample-1" deleted
```

Locate the TimesTen Operator

The TimesTen Operator is configured in your Kubernetes cluster using a Deployment. Kubernetes automatically monitors the TimesTen Operator and restarts it if it fails. The TimesTen Operator runs in a Pod and the name of the Operator begins with `timesten-operator`, followed by arbitrary characters to make the name unique. If you specify multiple replicas when you deploy the Operator, there are multiple Pods. Only one Pod is active at a time. The remainder of the Pods wait for the active to fail, and if it does, then one of the Pods becomes active. TimesTenClassic objects continue to function if the Operator fails. When a new Operator is started by Kubernetes, the Operator automatically monitors and manages existing TimesTenClassic objects.

To display the Pods that are running the TimesTen Operator, use the `kubectl get pods` command. In the following example, there is one Pod that is running the TimesTen Operator. For more information about the TimesTen Operator, see About the TimesTen Operator.

```
% kubectl get pods
NAME                                       READY   STATUS    RESTARTS   AGE
timesten-operator-5d7dcc7948-8mnz4         1/1     Running   0          3m21s
```

Modify TimesTen Connection Attributes

TimesTen uses connection attributes to define the attributes of a database. There are three types of connection attributes:

- Data store attributes: Define the characteristics of a database that can only be changed by destroying and recreating the database.
- First connection attributes: Define the characteristics of a database that can be changed by unloading and reloading the database into memory.
- General connection attributes: Control how applications access the database. These attributes persist for the duration of the connection.

For more information on TimesTen connection attributes, see List of Connection Attributes in the *Oracle TimesTen In-Memory Database Reference* and Connection Attributes for Data Manager DSNs or Server DSNs in the *Oracle TimesTen In-Memory Database Operations Guide*.

In a Kubernetes environment:

- You can only modify data store attributes by deleting the TimesTenClassic object and the PersistentVolumeClaims associated with the TimesTenClassic object. Doing so results in the deletion of the TimesTen databases.
- You can modify first connection and general connection attributes without deleting a TimesTenClassic object (which deletes the databases) and the PersistentVolumeClaims associated with the TimesTenClassic object. Note that there are TimesTen restrictions when modifying some of the first connection attributes.

To modify first or general connection attributes:

- You must first edit the `db.ini` file. Complete the procedure in the Manually Edit the db.ini File section. This section must be completed first.

Then, take these steps:

- If you are modifying first connection attributes, follow the procedure in the Modify First Connection Attributes section.

- If you are modifying general connection attributes, follow the procedure in the Modify General Connection Attributes section.

Manually Edit the db.ini File

Complete this section if you are modifying first or general connection attributes or both. This section must be completed before proceeding to the Modify First Connection Attributes or the Modify General Connection Attributes sections.

To modify first or general connection attribute requires a change in the `sys.odbc.ini` file.

If you have already created a TimesTenClassic object and you now want to change one or more first or general connection attributes in your `sys.odbc.ini` file, you must change the `db.ini` file.

The details as to how you should modify your `db.ini` file depends on the facility originally used to contain the `db.ini` file. (Possible facilities include ConfigMaps, Secrets, or init containers. See Populate the /ttconfig Directory.)

In this example, the ConfigMap facility was originally used to contain the `db.ini` file and to populate the `/ttconfig` directory of the TimesTen containers. The example modifies the `sample` ConfigMap.

The steps are as follows:

1. Use the `kubectl describe` command to review the contents of the `db.ini` file (represented in **bold**) located in the original `sample` ConfigMap.

   ```
   % kubectl describe configmap sample
   Name:         sample
   Namespace:    mynamespace
   Labels:       <none>
   Annotations:  <none>

   Data
   ====
   adminUser:
   ----
   sampleuser/samplepw

   db.ini:
   ----
   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ConnectionCharacterSet=AL32UTF8

   schema.sql:
   ----
   create sequence sampleuser.s;
   create table sampleuser.emp (id number not null primary key, name char (32));

   Events:  <none>
   ```

2. Use the `kubectl edit` command to modify the `db.ini` file in the original `sample` ConfigMap. Change the `PermSize` first connection attribute to `600` (represented in **bold**). Add the `TempSize` first connection attribute and set its value to `300` (represented in **bold**). Add the `ConnectionCharacterSet` connection attribute.

   ```
   % kubectl edit configmap sample
   # Please edit the object below. Lines beginning with a '#' will be ignored,
   # and an empty file will abort the edit. If an error occurs while saving this
   ```

```
# file will be reopened with the relevant failures.
#
apiVersion: v1
data:
  adminUser: |
    sampleuser/samplepw
  db.ini: |
    PermSize=600
    TempSize=300
    DatabaseCharacterSet=AL32UTF8
    ConnectionCharacterSet=AL32UTF8
  schema.sql: |
    create sequence sampleuser.s;
    create table sampleuser.emp (id number not null primary key, name char (32));
kind: ConfigMap
metadata:
  creationTimestamp: "2025-01-16T19:23:59Z"
  name: sample
  namespace: mynamespace
  resourceVersion: "71907255"
  selfLink: /api/v1/namespaces/mynamespace/configmaps/sample
 uid: 0171ff7f-f789-11ea-82ad-0a580aed0453
...
configmap/sample edited
```

3. Use the `kubectl describe` command to verify the changes to the `sample` ConfigMap. (The changes are represented in **bold**.)

```
% kubectl describe configmap sample
Name:         sample
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>

Data
====
schema.sql:
----
create sequence sampleuser.s;
create table sampleuser.emp (id number not null primary key, name char (32));

adminUser:
----
sampleuser/samplepw

db.ini:
----
PermSize=600
TempSize=300
DatabaseCharacterSet=AL32UTF8
ConnectionCharacterSet=AL32UTF8

Events:  <none>
```

You have successfully changed the `sample` ConfigMap. If you are modifying first connection attributes, proceed to the Modify First Connection Attributes section. If you are modifying only general connection attributes, proceed to the Modify General Connection Attributes section.

Modify First Connection Attributes

If you have not modified the `db.ini` file, proceed to the Manually Edit the db.ini File section. You must now delete the standby Pod and then delete the active Pod. When you delete a Pod that contains a container running TimesTen, the Operator creates a new Pod to replace the deleted Pod. This new Pod contains a new `sys.odbc.ini` file which is created from the contents of the `db.ini` file located in the `/ttconfig` directory.

Perform these steps to delete the standby Pod.

1. Use the `kubectl get` command to determine which Pod is the standby Pod for the `sample` TimesTenClassic object. The active Pod is the Pod represented in the `ACTIVE` column. The standby Pod is the other Pod (not represented in the `ACTIVE` column). Therefore, for the `sample` TimesTenClassic object, the active Pod is `sample-0`, (represented in **bold**) and the standby Pod is `sample-1`.

   ```
   % kubectl get ttc sample
   NAME     STATE    ACTIVE     AGE
   sample   Normal   sample-0   47h
   ```

2. Delete the standby Pod (`sample-1`, in this example). This results in the Operator creating a new standby Pod to replace the deleted Pod. When the new standby Pod is created, it will use the newly modified `sample` ConfigMap. (You modified this ConfigMap in the Manually Edit the db.ini File section.)

   ```
   % kubectl delete pod sample-1
   pod "sample-1" deleted
   ```

3. Use the `kubectl get` command to verify the standby Pod is up and running and the state is `Normal`.

   Note that the state is `StandbyDown` (represented in **bold**).

   ```
   % kubectl get ttc sample
   NAME     STATE         ACTIVE     AGE
   sample   StandbyDown   sample-0   47h
   ```

   Wait a few minutes, then run the command again. Note that the state has changed to `Normal` (represented in **bold**).

   ```
   % kubectl get ttc sample
   NAME     STATE    ACTIVE     AGE
   sample   Normal   sample-0   47h
   ```

4. Use the `kubectl exec -it` command to invoke the shell in the standby Pod (`sample-1`, in this example). Then, run the `ttIsql` utility to connect to the `sample` database. Note the new `PermSize` value of `600` and the new `TempSize` value of `300` in the connection output (represented in **bold**).

   ```
   % kubectl exec -it sample-1 -c tt -- /bin/bash
   % ttIsql sample
   Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
   Type ? or "help" for help, type "exit" to quit ttIsql.
   connect "DSN=sample";
   Connection successful:
   DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
   DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;
   AutoCreate=0;PermSize=600;TempSize=300;DDLReplicationLevel=3;
   ForceDisconnectEnabled=1;
   (Default setting AutoCommit=1)
   ```

5. Fail over from the active Pod to the standby Pod. See "Fail Over" for details of the fail over process. Before you begin this step, ensure you quiesce your applications and you use the `ttRepAdmin -wait` command to wait until replication is caught up, such that all transactions that were executed on the active database have been replicated to the standby database. Once the standby is caught up, fail over from the active database to the standby by

deleting the active Pod. When you delete the active Pod, the Operator automatically detects the failure and promotes the standby database to be the active.

Delete the active Pod (`sample-0`, in this example).

```
% kubectl delete pod sample-0
pod "sample-0" deleted
```

6. Wait a few minutes, then use the `kubectl get` command to verify the active Pod is now `sample-1` for the `sample` TimesTenClassic object and the state is `Normal` (represented in **bold**).

```
% kubectl get ttc sample
NAME     STATE    ACTIVE     AGE
sample   Normal   sample-1   47h
```

7. Use the `kubectl exec -it` command to invoke the shell in the active Pod (`sample-1`, in this example). Then, run the `ttIsql` utility to connect to the `sample` database. Note the new `PermSize` value of `600` and the new `TempSize` value of `300` in the connection output (represented in **bold**).

```
% kubectl exec -it sample-1 -c tt -- /bin/bash
Last login: Thu Jan 16 15:50:29 UTC 2025 on pts/0
[timesten@sample-1 ~]$ ttIsql sample

Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful:
DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;
AutoCreate=0;PermSize=600;TempSize=300;DDLReplicationLevel=3;
ForceDisconnectEnabled=1;
(Default setting AutoCommit=1)
```

8. Use the `kubectl exec -it` command to invoke the shell in the standby Pod (`sample-0`, in this example). Then, run the `ttIsql` utility to connect to the `sample` database. Note the new `PermSize` value of `600` and the new `TempSize` value of `300` in the connection output (represented in **bold**).

```
% kubectl exec -it sample-0 -c tt -- /bin/bash
% ttIsql sample

Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful:
DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;
AutoCreate=0;PermSize=600;TempSize=300;DDLReplicationLevel=3;
ForceDisconnectEnabled=1;
(Default setting AutoCommit=1)
```

You have successfully modified the `PermSize` and the `TempSize` first connection attributes.

Modify General Connection Attributes

If you have not modified the `db.ini` file, proceed to the Manually Edit the db.ini File section. You can either directly modify the `sys.odbc.ini` file for the active TimesTen database and the `sys.odbc.ini` file for the standby TimesTen database or you can follow the steps in the Modify First Connection Attributes section. The first approach (modifying the `sys.odbc.ini` file directly) is less disruptive.

This section discusses the procedure for directly modifying the `sys.odbc.ini` files.

The `sys.odbc.ini` file is located in the TimesTen container of the Pod containing the active TimesTen database and in the TimesTen container of the Pod containing the standby TimesTen database. After you complete the modifications to the `sys.odbc.ini` files, subsequent applications can connect to the database using these general connection attributes.

This example illustrates how to edit the `sys.odbc.ini` files.

1. Use the `kubectl exec -it` command to invoke a shell in the active Pod. (In this example, `sample-0` is the active Pod.)

   ```
   % kubectl exec -it sample-0 -c tt -- /bin/bash
   Last login: Thu Jan 16 22:43:26 UTC 2025 on pts/8
   ```

2. Verify the current directory (`/tt/home/timesten`).

   ```
   % pwd
   /tt/home/timesten
   ```

3. Navigate to the directory where the `sys.odbc.ini` file is located. The `sys.odbc.ini` file is located in the `/tt/home/timesten/instances/instance1/conf` directory. Therefore, navigate to the `instances/instance1/conf` directory.

   ```
   % cd instances/instance1/conf
   ```

4. Edit the `sys.odbc.ini` file, adding, modifying, or deleting the general connection attributes for your DSN. (`sample`, in this example.)

   Note

   Ensure that you only make modifications to the TimesTen general connection attributes. Data store attributes and first connection attributes cannot be modified by directly editing the `sys.odbc.ini` file.

   This example modifies the `sample` DSN, adding the `ConnectionCharacterSet` general connection attribute and setting its value equal to `AL32UTF8` (represented in **bold**).

   ```
   vi sys.odbc.ini

   [ODBC Data Sources]
   sample=TimesTen 26.1 Driver
   tt=TimesTen 26.1 Driver

   [sample]
   Datastore=/tt/home/timesten/datastore/sample
   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ConnectionCharacterSet=AL32UTF8
   DDLReplicationLevel=3
   ```

```
AutoCreate=0
ForceDisconnectEnabled=1
...
```

5. Use the `ttIsql` utility to connect to the `sample` database and verify the value of the `ConnectionCharacterSet` attribute is `AL32UTF8` (represented in **bold**).

```
% ttIsql sample

Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful:
DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;
AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled=1;
(Default setting AutoCommit=1)
```

You have successfully modified the `sys.odbc.ini` file located in the TimesTen container of the active Pod (in this example, `sample-0`). Use the same procedure to modify the `sys.odbc.ini` file located in the TimesTen container of the standby Pod (in this example, `sample-1`).

For example:

1. Use the `kubectl exec -it` command to invoke a shell in the standby Pod (`sample-1`, in this example).

```
% kubectl exec -it sample-1 -c tt -- /bin/bash
Last login: Thu Jan 16 23:08:08 UTC 2025 on pts/0
```

2. Verify the current directory (`/tt/home/timesten`).

```
% pwd
/tt/home/timesten
```

3. Navigate to the directory where the `sys.odbc.ini` file is located. The `sys.odbc.ini` file is located in the `/tt/home/timesten/instances/instance1/conf` directory. Therefore, navigate to the `instances/instance1/conf` directory.

```
% cd instances/instance1/conf
```

4. Edit the `sys.odbc.ini` file, adding, modifying, or deleting the same general connection attributes that you modified for the active database. Therefore, this example modifies the `sample` DSN, adding the `ConnectionCharacterSet` general connection attribute and setting its value equal to `AL32UTF8` (represented in **bold**).

```
vi sys.odbc.ini

[ODBC Data Sources]
sample=TimesTen 26.1 Driver
tt=TimesTen 26.1 Driver

[sample]
Datastore=/tt/home/timesten/datastore/sample
PermSize=200
DatabaseCharacterSet=AL32UTF8
ConnectionCharacterSet=AL32UTF8
DDLReplicationLevel=3
AutoCreate=0
ForceDisconnectEnabled=1
...
```

5. Use the `ttIsql` utility to connect to the `sample` database and verify the value of the `ConnectionCharacterSet` attribute is `AL32UTF8` (represented in **bold**).

```
% ttIsql sample

Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful:
DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;
AutoCreate=0;PermSize=200;DDLReplicationLevel=3;ForceDisconnectEnabled=1;
(Default setting AutoCommit=1)
```

You have successfully modified the `sys.odbc.ini` file located in the TimesTen container of the active Pod (`sample-0`) and the `sys.odbc.ini` file located in the TimesTen container of the standby Pod (`sample-1`). The `ConnectionCharacterSet` general connection attribute has also been modified.

11

Optimize Client/Server Performance

This chapter discusses how to optimize client/server performance. It discusses NodePort Services and the TimesTen Connection Manager.

Topics:

About Client/Server Challenges

You may want to access TimesTen databases that are inside a Kubernetes cluster by using client/server from outside the cluster. While this is possible, it presents the following challenges:

- Clients outside the Kubernetes cluster access TimesTen databases inside the cluster by using a NodePort Service. Client applications can connect to any node in the Kubernetes cluster. The node that the application connects to may not be a node on which TimesTen is running. Kubernetes routes the connection to a TimesTen instance in the cluster. This works seamlessly, but results in additional network round trips and reduced performance.
- If changes from DML operations are coming from client/server applications, it is important to route those connections to active TimesTen instances as they are the only writable instances. For read-only applications, it is desirable to route connections to both active and standby instances, so that standby instances can participate in the workload.

The TimesTen Operator uses NodePort Services and provides a Connection Manager that provides solutions to these client/server challenges and allows applications to avoid these issues.

About NodePort Services

To implement this feature, the TimesTen Operator creates additional NodePort Services. The TimesTen Operator creates one Service for each Pod that the Operator creates.

For example, if you configure a TimesTenClassic object called `sample` to have three Pods, the TimesTen Operator creates three NodePort Services called `sample-np-0`, `sample-np-1`, and `sample-np-2`. Each Service maps to the corresponding Pod. For example, NodePort Service `sample-np-1` maps to Pod `sample-1`. Kubernetes deletes these Services when you delete a TimesTenClassic object.

Since these are NodePort Services, Kubernetes automatically assigns a port number on the cluster's external network that can be used by applications outside the cluster to access it. The port numbers that Kubernetes assigns are unpredictable. However, after creating NodePort

Services, the TimesTen Operator can query the Service to see what external port number Kubernetes has assigned.

About the Connection Manager

The TimesTen Operator functions as an https server. It provides http and https servers running on a number of ports, including:

- Metrics (port 8080): Used by Prometheus to scrape metrics about the TimesTen Operator. The `/metrics` URL endpoint is available for this purpose. It exposes metrics from the TimesTen Operator to Prometheus.
- Probe (port 8081): Used by Kubernetes to determine the readiness of the TimesTen Operator. The `/probe` URL endpoint is available for this purpose.

This feature adds several new endpoints to the `/metrics` server. These endpoints allow applications to query information about the location and health of TimesTen databases, which are managed by the TimesTen Operator.

These endpoints allow applications to use an https GET to retrieve a TimesTen connection string that can then be used to access TimesTen databases optimally. Applications can request connection strings that are usable either from inside the cluster or from outside the cluster.

Here is the syntax:

```
/connstr/v1/namespace/ttc_name/access_mode/in_or_out
```

where:

- `connstr/v1`: Is a hardcoded, constant string that is part of the API. Do not change this parameter.
- `namespace`: Is the namespace in which the TimesTenClassic object being queried resides.
- `ttc_name`: Is the name of the TimesTenClassic object being queried.
- `access_mode`: Describes the type of access the application wants in order to get to the TimesTen database. Valid values are as follows:
  - `readable`: Indicates that the application wants to issue reads against the database.
  - `writable`: Indicates that the application wants to make changes to the database.
  - `readonly`: Indicates that the application wants to access a read-only, non-writable instance of the database.

  The difference between `readable` and `readonly` is that databases that are `writable` are also `readable`, but they are not `readonly`.
- `in_or_out`: Is either:
  - `internal`: Indicates that the application wants to receive a connection string that is viable from inside the cluster.
  - `external`: Indicates that the application wants to receive a connection string that is viable from outside the cluster.

The response is a JSON object that includes a TimesTen client/server connection string containing `TTC_SERVERn` and `TTC_SERVER_DSN` connection attributes that can be used to access the desired database in the desired mode. For more information about these connection attributes, see Client and Server Connection Attributes in the *Oracle TimesTen In-Memory Database Reference*.

The TimesTen Operator updates this information and stores it in the TimesTenClassic object's `status` field. When an application queries this data, the TimesTen Operator GETs the TimesTenClassic object from Kubernetes and retrieves the information from the object's `status`. The TimesTen Operator then returns the information to the querying application.

How to Use the Connection Manager

Let's look at an example to illustrate how the Connection Manager works.

Consider the following scenario:

- The cluster consists of the following nodes:
  - `node1`: External IP address 1.2.3.4
  - `node2`: External IP address 1.2.3.5
  - `node3`: External IP address 1.2.3.6
- An active/standby TimesTenClassic object called `sample` in the `payroll` namespace exists. The following Pods also exist for this object:
  - `sample-0`:
    - Running on `node1`
    - Contains the active database
    - Internal IP address: 9.0.0.1
    - Associated NodePort Service `sample-np-0`: Is assigned external port number `32444`
  - `sample-1`:
    - Running on `node3`
    - Contains the standby database
    - Internal IP address: 9.0.0.77
    - Associated NodePort Service `sample-np-1`: Is assigned external port number `32445`

If you issue a GET to `/connstr/v1/payroll/sample/readable/external`, you receive the following connection string:

```
TTC_SERVER1=1.2.3.4/32444;TTC_SERVER2=1.2.3.6/32445;TTC_SERVER_DSN=sample
```

If you issue a GET to `/connstr/1/payroll/sample/writable/external`, you receive the following connection string:

```
TTC_SERVER1=1.2.3.4/32444;TTC_SERVER_DSN=sample
```

If you issue a GET to `/connstr/v1/payroll/sample/readable/internal`, you receive the following connection string:

```
TTC_SERVER1=9.0.0.1/6625;TTC_SERVER2=9.0.0.77/6625;TTC_SERVER_DSN=sample
```

If you issues a GET to `/connstr/v1/payroll/sample/writable/internal`, you receive the following connection string:

```
TTC_SERVER1=9.0.0.77/6625;TTC_SERVER_DSN=sample
```

About Accessing the Endpoint from Inside the Cluster

Applications running inside the cluster can access the TimesTen Operator at `timesten-operator.`*`namespace`*`.svc.cluster.local:8080` where `namespace` is the name of your namespace.

The `metrics` endpoint by default uses https, secured with a self-signed certificate created by the TimesTen Operator. Applications running inside the cluster can get the appropriate certificate to allow them to access the endpoint by mounting the Kubernetes Secret called `timesten-operator-metrics-client`. The TimesTen Operator automatically creates this Secret.

The Secret contains the following entries:

- `ca.crt` : Adds the TimesTen Operator's certificate to the list of certificates that the application accepts (or trusts).
- `client.crt`: Contains a client certificate that the TimesTen Operator trusts.
- `client.key`: Contains the private key for the client certificate.

To access the Connection Manager API, applications must authenticate to the TimesTen Operator using this information.

About Accessing the Endpoint from Outside the Cluster

When the TimesTen Operator starts up, it creates a NodePort Service that maps to the `metrics` endpoint. This allows applications outside the cluster to access this information. The TimesTen Operator attempts to create this NodePort Service on an external port number that you provide. If successful, applications outside the cluster can then issue GETs to this port number on any node in the cluster in order to retrieve the TimesTen connection strings. It is up to you to make the IP addresses of cluster nodes and the external port number available to applications.

The `metrics` endpoint by default uses https, secured with a self-signed certificate created by the TimesTen Operator. Applications running inside the cluster can get the appropriate certificate to allow them to access the endpoint by mounting the Kubernetes Secret called `timesten-operator-metrics-client`. The TimesTen Operator automatically creates this Secret.

However, applications outside the cluster cannot directly access this Secret or other Secrets within the cluster. You must manually extract the contents of the `timesten-operator-metrics-client` Secret and make it available to applications outside the cluster that want to use the Connection Manager API.

The Secret contains the following entries:

- `ca.crt` : Adds the TimesTen Operator's certificate to the list of certificates that the application accepts (or trusts).
- `client.crt`: Contains a client certificate that the TimesTen Operator trusts.
- `client.key`: Contains the private key for the client certificate.

To access the Connection Manager API, applications must authenticate to the TimesTen Operator using this information.

About Accessing TimesTen

Once applications receive a connection string from the Connection Manager, they may then add additional information to the connection string before presenting it to TimesTen. For example, the `UID` and `PWD` connection attributes can be added to authenticate the database as well as additional attributes can be added, such as character set, lock timeouts, and so on.

About Handling Failures

Once connected to a database, the application can use TimesTen normally. At some point, the application's connection to TimesTen may fail. In such circumstances, applications should not attempt to reconnect to the database using the connection string that applications were previously using. Rather, applications should request a new connection string from the Connection Manager and should use it instead.

About the NodePort Service for the Connection Manager

The TimesTen Operator creates a NodePort Service that enables access to the Connection Manager API from outside the cluster. The Service routes incoming requests to the current leader Operator instance. The service is called `timesten-operator-np`.

By default the NodePort Service is configured to use port number `32625`. You can override this port number by using the `TT_CONNECTION_MANAGER_NODEPORT` environment variable in the `operator.yaml` or `cluster_operator.yaml` YAML files or by using the `operatorNodePort` value in the `ttoperator` or `ttclusteroperator` Helm charts.

Note

Kubernetes allows NodePort Services to use only port numbers between `30000` and `32767`.

About the TimesTen Operator Configuration

Here is the TimesTen Operator configuration for using the Connection Manager to optimize client/server performance:

- `TT_CONNECTION_MANAGER`: If defined and set to `1`, this environment variable enables the Connection Manager. By default, the value is set to `1` in the `operator.yaml` and `cluster_operator.yaml` YAML manifest files.

  `connectionManager`: If defined and set to `true` in the `ttoperator` or `ttclusteroperator` Helm charts, the Connection Manager is enabled. The default is `true` and is set in the `ttoperator` and `ttclusteroperator` Helm charts.

  If you disable metrics for the TimesTen Operator, or you are not using https for metrics, the Connection Manager is not enabled. For example, if you set `METRICS_SCHEME` to `http` or `EXPOSE_METRICS` to `0` (or the equivalent in the Helm charts), then `TT_CONNECTION_MANAGER` (and `connectionManager`) is ignored and treated as `0` (or `false`).
- `TT_CONNECTION_MANAGER_NODEPORT` environment variable (in `operator.yaml` and `cluster_operator.yaml`) and the `operatorNodePort` value (in the `ttoperator` and

`ttclusteroperator` Helm charts): Use to change the port number on which the Connection Manager API is available for applications outside the cluster. The default is `32625`.

- `TT_OPERATOR_SAN` environment variable (in `operator.yaml` and `cluster_operator.yaml`) and the `operatorSAN` value (in the `ttoperator` and `ttclusteroperator` Helm charts): Use to add subject alternate names (SANs) to the TLS certificate that the TimesTen Operator creates to control access to the TimesTen Operator metrics and to the Connection Manager API.
  - If you use metrics and the Connection Manager API from inside the cluster only, you do not need to define this environment variable in the YAML manifest files (or define the value in the Helm charts).
  - If you use either metrics or the Connection Manager API or both from outside the cluster, you must define a SAN for the nodes in the cluster. By default, no SAN is specified.

For more information, see TimesTen Kubernetes Operator Environment Variables and Helm Charts for the TimesTen Kubernetes Operator.

Normal http error codes indicate if the request is invalid.

If a valid request is received, a JSON object is returned in the following format:

```
{ "status": 0 [, "error": "the error"] [, "connstr": "TTC_SERVER1=..."]}
```

where:

- `status`: Is a numeric indication as to whether the request was successful or not. A value of `0` indicates success.
- `error`: If `status` is not equal to `0`, this is a string that explains the error.
- `connstr`: If `status` is equal to `0`, this is the connection string that is returned.

12

Expose TimesTen Metrics with the TimesTen Kubernetes Operator

The TimesTen Kubernetes Operator (TimesTen Operator) can expose TimesTen metrics to Prometheus or any other scraping mechanism. This chapter shows you how.

Topics:

Overview of TimesTen Metrics

There are several TimesTen metrics that can be exposed to Prometheus or another scraping mechanism. These metrics are collected from a variety of sources, including TimesTen system tables and views and TimesTen built-in procedures and utilities. For more information about TimesTen metrics, see The Metrics Supported by the TimesTen Exporter in the *Oracle TimesTen In-Memory Database Monitoring and Troubleshooting Guide*.

Prometheus is an open source monitoring and alerting toolkit. It collects and stores metrics from monitored targets by scraping the http (or https) `metrics` endpoint on these targets.

TimesTen exports TimesTen metrics to Prometheus by using the TimesTen `ttExporter` (TimesTen exporter) utility. The TimesTen exporter presents itself as an http or https server. When the TimesTen exporter receives an http or https request to the `/metrics` endpoint, it retrieves the TimesTen metrics from each database that it monitors and prepares a plain text http or https response with the metrics.

The TimesTen exporter converts TimesTen metrics into a form supported by Prometheus. This simple integration lets you monitor the health and operation of your TimesTen databases.

For information about Prometheus and the TimesTen exporter, see About Prometheus and About the TimesTen Exporter in the *Oracle TimesTen In-Memory Database Monitoring and Troubleshooting Guide*.

Overview of the TimesTen Kubernetes Operator and the TimesTen Exporter

The TimesTen Operator supports the TimesTen exporter and lets you configure TimesTenClassic objects to use this TimesTen exporter. Once configured, the TimesTen Operator starts, stops, and manages the TimesTen exporter. As the TimesTen exporter collects metrics from the TimesTen databases running in your Kubernetes environment, the TimesTen Operator works to expose these metrics to Prometheus.

The TimesTen exporter runs in its own `exporter` container. This container exists in the same TimesTen Pods as the `tt` and the `daemonlog` containers. These TimesTen Pods run in your Kubernetes cluster.

The TimesTen Operator creates the Pods that are running TimesTen with the Kubernetes `shareProcessNamespace` Pod attribute. This attribute allows the TimesTen exporter that is running in the `exporter` container to access TimesTen that is running in the `tt` container, both of which are in the TimesTen Pod. For more information about the `shareProcessNamespace` attribute, see Share Process Namespace between Containers in a Pod in the Kubernetes documentation.

The TimesTen Operator configures the `exporter` container with the same TimesTen container image as the `tt` and the `daemonlog` containers. If the TimesTen exporter fails or exits, Kubernetes destroys the `exporter` container and creates another one to take its place. Kubernetes monitors and manages the `exporter` container. Because the lifecycle of individual containers in a Pod are independent, the TimesTen Operator ensures that the `ttExporter` command starts after TimesTen. The TimesTen Operator waits until the TimesTen agent creates the TimesTen instance and waits until the TimesTen main daemon is running in the `tt` container of the TimesTen Pod. The Operator then starts the TimesTen exporter in the `exporter` container of the same TimesTen Pod.

Once configured, the TimesTen exporter functions as an http or https server. It listens for incoming GET requests and responds to them by gathering a set of metrics from TimesTen. It then returns these metrics as the response to the GET request.

To facilitate the listening process, the TimesTen Operator creates a Kubernetes headless Service. This Service exposes the port on which the TimesTen exporter is listening to the remainder of the Kubernetes cluster. This lets a Prometheus server running in the cluster to fetch the TimesTen metrics from TimesTen and process them.

About the Prometheus Operator

In Overview of the TimesTen Kubernetes Operator and the TimesTen Exporter, we discussed how the TimesTen Operator and the TimesTen exporter work together to collect and export TimesTen metrics. Now let's look at how we can expose these metrics to Prometheus.

Note

You can expose TimesTen metrics to any scraping target. Our documentation focuses on Prometheus.

There are several ways to configure Prometheus in Kubernetes. One of the most popular is the Prometheus Operator. The Prometheus Operator simplifies the deployment, monitoring, and management of Prometheus in Kubernetes.

Similar to the TimesTen Kubernetes Operator, the Prometheus Operator add several custom resource definitions (CRDs) to Kubernetes. Just as you deploy TimesTen by creating an object of type TimesTenClassic, deploying Prometheus in Kubernetes involves creating an object of type *Prometheus*. The Prometheus Operator automatically detects the creation of such an object and responds by starting a server using the configuration included in the object.

Note

It is beyond the scope of this book to detail how to create an object of type Prometheus.

The Prometheus Operator also simplifies the configuration of Prometheus servers that it deploys. The Prometheus Operator can automatically edit the Prometheus server's configuration files to include data sources that should be scraped from the `/metrics` endpoint. This is done through the creation of Kubernetes objects of type *ServiceMonitor* and of type *PodMonitor*. (The ServiceMonitor object type is discussed in About Creating ServiceMonitor Objects.)

Let's look at a basic example of a PodMonitor object:

```
apiVersion: monitoring.coreos.com/v1
kind: PodMonitor
metadata:
  name: sample
spec:
  selector:
    matchLabels:
      app: sample
  podMetricsEndpoints:
  - port: metrics
```

If you create such a PodMonitor object, the Prometheus Operator automatically responds by editing the Prometheus server's configuration files to cause the Prometheus server to scrape metrics from any Pod created with a label of `app: sample`. All Pods with the specified label automatically appear as scrape targets in Kubernetes. As Pods matching the selector are created or deleted, the Prometheus configuration is automatically kept in synchronization.

Using a Prometheus Operator offers a simplified approach to not only deploying, managing, and monitoring Prometheus, but also configuring Prometheus servers.

About Exposing TimesTen Metrics

The TimesTen Operator supports the TimesTen exporter, providing the ability for TimesTen databases deployed in your Kubernetes cluster to have TimesTen metrics exported. In addition, the Prometheus Operator configures and stands up Prometheus servers and creates and manages configuration files associated with these Prometheus servers. However, there are additional tasks that Prometheus requires to scrape TimesTen metrics.

For example:

- If you are using https to serve TimesTen metrics, an Oracle Wallet and certificates must be created.
- The certificates must be made available to Prometheus.
- Prometheus configuration files must be edited to cause Prometheus to scrape metrics from TimesTen. This is true whether TimesTen metrics are served using https or http.

Let's look at these tasks, examine our options for completing these tasks, and discuss how the TimesTen Operator can automatically perform these tasks for you.

Starting with TimesTen release 22.1, the TimesTen Operator automatically exports and exposes TimesTen metrics. In addition, if the Prometheus Operator is installed in your Kubernetes cluster, the TimesTen Operator provides Prometheus with all the information it needs to scrape TimesTen metrics from TimesTen databases.

Let's look at how the TimesTen Operator does this.

By default, the TimesTen Operator does the following:

- Exports and exposes TimesTen metrics from TimesTen databases deployed in your Kubernetes cluster.
- Uses https/Transport Layer Security (mutual TLS) to make these metrics available.
- If the Prometheus Operator is installed, creates the necessary objects to cause Prometheus to be automatically modified, which then causes Prometheus to scrape TimesTen metrics from the TimesTen databases.
- Exposes TimesTen metrics outside of the TimesTen Pods.

Although this default behavior is recommended, you have the option of changing the default behavior. Let's examine our options:

- https or http?: TimesTen metrics are available by https (default) or http.
- Create a Kubernetes PodMonitor object?: If the Prometheus Operator is installed in your Kubernetes cluster, the TimesTen Operator can create a PodMonitor object. This object contains the information needed by the Prometheus Operator to configure TimesTen databases as a scrape target. If the Prometheus Operator has been installed in your Kubernetes cluster, then by default the TimesTen Operator attempts to create a PodMonitor object.
- Expose TimesTen metrics outside of the TimesTen Pods?: The TimesTen exporter listens on and accepts GETs on the `*sampleobject*.*mynamespace*.svc.cluster.local:8080/metrics` endpoint (where `sampleobject` is the name of a TimesTenClassic object and `*mynamespace*` is the name of your namespace). By default, the TimesTen Operator deploys a Kubernetes Service that makes this endpoint available to other Pods in the Kubernetes cluster.

Note

Having the TimesTen Operator automatically expose TimesTen metrics is not available in TimesTen release 18.1. This functionality is available in TimesTen release 22.1 and later.

Now let's look at how we can change this default behavior.

A TimesTenClassic object that is deployed in your namespace has specific datum associated with the object. These datum define the characteristics of a TimesTenClassic object, including the TimesTen databases associated with the object. You have the option of customizing a

TimesTenClassic object by specifying values for particular datum in the object's YAML manifest file.

For exposing TimesTen metrics, the TimesTen Operator provides the `.spec.ttspec.prometheus` datum/clause and provides specific datum for use within this clause. This clause and its associated datum determine if and how the TimesTen Operator exports and exposes TimesTen metrics.

Let's look at the specific datum in the `.spec.ttspec.prometheus` clause in greater detail:

- `.spec.ttspec.prometheus.publish`: Determines if the TimesTen Operator provisions an `exporter` container for the TimesTen exporter. The default is `true`. We discuss this in About Choosing to Expose TimesTen Metrics.
- `.spec.ttspec.prometheus.insecure`: Determines if TimesTen metrics are served using https or http. If the value is `false` or not specified, TimesTen metrics are served using https. If the value is `true`, TimesTen metrics are served using http. For more information, see About Using http or https for TimesTen Metrics.
- `.spec.ttspec.prometheus.certSecret`: If specified, contains a Kubernetes Secret that you have previously created. This Secret contains an Oracle Wallet and the necessary certificates for https. If not specified, the TimesTen Operator automatically creates an Oracle Wallet, the necessary certificates, and the Kubernetes Secrets.

  We recommend that you do not specify `.spec.ttspec.prometheus.certSecret` and instead let the TimesTen Operator automate this process for you. For more information, see About Transport Layer Security (mutual TLS) Certificates for TimesTen Metrics. If you want to specify `.spec.ttspec.prometheus.certSecret`, see Create Your Own Oracle Wallet, Certificates, and Secrets for Exposing TimesTen Metrics.
- `.spec.ttspec.prometheus.createPodMonitors`: Determines if the TimesTen Operator should create a PodMonitor object. The default is `true`. We discuss this in About Creating PodMonitor Objects.

For additional information about `.spec.ttspec.prometheus` and its associated datum, see TimesTenClassicSpecSpecPrometheus.

About Using http or https for TimesTen Metrics

TimesTen metrics are available by http or https.

The default behavior is https and is discussed in About Transport Layer Security (mutual TLS) Certificates for TimesTen Metrics.

To cause the TimesTen Operator to use http for TimesTen metrics, specify the `.spec.ttspec.prometheus.insecure` datum in a TimesTenClassic object YAML manifest file.

Here is a code snippet of a TimesTenClassic object YAML manifest file showing you how to do this:

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: usehttp
spec:
  ttspec:
…
    prometheus:
      insecure: true
      port: 7777
```

Note the following:

- The `.spec.ttspec.insecure` datum is specified in the `.spec.ttspec.prometheus` clause of the TimesTenClassic object. This causes the TimesTen Operator to configure the TimesTen exporter to serve TimesTen metrics using http.

  The `.spec.ttspec.port` datum is specified. This is the port on which the TimesTen exporter listens. The causes the TimesTen Operator to set up the http server on TCP port 7777 in each TimesTen Pod.

About Transport Layer Security (mutual TLS) Certificates for TimesTen Metrics

When https is used, the TimesTen Operator automatically creates self-signed certificates. The TimesTen Operator also creates two Kubernetes Secrets to hold these certificates.

As an example, for a TimesTen object called `sample`, these Secrets are automatically created:

- `sample-metrics`: This Secret is automatically mounted in the TimesTen exporter containers of the TimesTen Pods. It contains an Oracle Wallet, which contains all certificates needed by the TimesTen exporter for https.
- `sample-metrics-client`: This Secret contains files that a Prometheus server (or other scraper) requires to scrape TimesTen metrics. This Secret contains the following three files:
  - `ca.crt`: The Certificate Authority certificate needed by the client to authenticate the self-signed certificate used by the TimesTen exporter.
  - `client.crt`: The client certificate that the TimesTen exporter uses to authenticate any clients that try to scrape metrics from it.
  - `client.key`: The private key that is associated with the `client.crt` client certificate.

Both Secrets are created with appropriate Kubernetes owner references. If you delete the associated TimesTenClassic object, these Secrets are automatically deleted.

Although not recommended, you have the option of creating your own certificates to serve TimesTen metrics using https. See Create Your Own Oracle Wallet, Certificates, and Secrets for Exposing TimesTen Metrics.

Note

If TimesTen metrics are served by using either http or https whereby you create your own self-signed certificates, then the TimesTen Operator does not automatically create certificates, Oracle Wallets, or Kubernetes Secrets.

About Creating PodMonitor Objects

By default, if the Prometheus Operator has been installed in your Kubernetes cluster, the TimesTen Operator automatically creates PodMonitor objects when it provisions TimesTen in your namespace. Specifically, the TimesTen Operator automatically creates a PodMonitor object for each deployed TimesTenClassic object.

This automates all of the steps required to get TimesTen metrics into Prometheus. As TimesTen objects are created and deleted, the appropriate scrape targets are automatically provisioned and removed from the Prometheus configuration without any intervention by you.

Although recommended, this is an optional capability. If you choose not to use the Prometheus Operator, you can export TimesTen metrics into Prometheus yourself. The Prometheus Operator is not a prerequisite for using the TimesTen Operator.

If you have installed the Prometheus Operator and you do not want the TimesTen Operator to automatically create PodMonitor objects, set the `.spec.ttspec.prometheus.createPodMonitors` datum of your TimesTenClassic object to `false`.

This capability is available whether a TimesTenClassic object is using http or https. It is also available with TimesTen Operator-created certificates and Secrets.

However, this capability is not available if you specify the `.spec.ttspec.prometheus.certSecret` datum in a TimesTenClassic object definition. If you provide your own Kubernetes Secret that contains your own Oracle Wallet (and this Oracle Wallet contains the necessary certificates for using https), the TimesTen Operator cannot automatically produce a PodMonitor object with sufficient information to allow Prometheus to access TimesTen. In this case, you must create your own PodMonitor objects, or otherwise edit Prometheus configuration files to access TimesTen and have TimesTen metrics scraped.

If the TimesTen Operator attempts to create a PodMonitor object and is unable to do so, the TimesTen Operator generates an appropriate Event and continues on with provisioning and other normal operations. This can happen if the Prometheus Operator is not installed in your Kubernetes cluster or if the TimesTen Operator has not been granted appropriate role-based access control (RBAC) privileges in your Kubernetes cluster. For more information about RBAC privileges, see https://kubernetes.io/docs/reference/access-authn-authz/rbac/.

A PodMonitor object created by the TimesTen Operator has an owner reference to the appropriate TimesTenClassic object. This ensures that the PodMonitor object is automatically deleted if the TimesTenClassic object is deleted.

Note

The `.spec.ttspec.prometheus.createPodMonitors` datum can be added to new TimesTenClassic objects, but cannot be added to existing objects (by using the `kubectl upgrade` or the `kubectl patch` commands or by other means).

For more information about PodMonitor objects, see https://prometheus-operator.dev/docs/getting-started/design/#podmonitor.

About the TimesTen Metrics Service

The TimesTen Operator automatically creates a Kubernetes Service for the TimesTen exporter. This Service exposes the port on which the TimesTen exporter listens to the Pods in the Kubernetes cluster. This Service exposes the port at `*sample*.*mynamespace*.svc.cluster.local:*port*/metrics` where:

- *`sample`* is the name of a TimesTenClassic object.
- *`mynamespace`* is the name of your namespace.
- *`port`* is the port number on which the TimesTen exporter listens.

The default port is 8888.

You can change the port on which the TimesTen exporter listens by specifying the `.spec.ttspec.prometheus.port` datum in a TimesTenClassic object YAML manifest file.

Here is a code snippet of a TimesTenClassic object YAML manifest file showing the `.spec.ttspec.prometheus.port` datum.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: sample
spec:
  ttspec:
…
    prometheus:
      port: 7777
```

In this snippet, the TimesTen exporter listens on port 7777.

About Choosing to Expose TimesTen Metrics

By default, the TimesTen Operator exposes TimesTen metrics for TimesTenClassic objects.

You have the option of not exposing TimesTen metrics by setting the `.spec.ttspec.prometheus.publish` datum to `false` in a TimesTenClassic object YAML manifest file. Doing so causes the TimesTen Operator to not provision an `exporter` container for the TimesTen exporter. If an `exporter` container is not provisioned, the TimesTen exporter is not configured, started, or managed. In this case, TimesTen metrics for the databases associated with this TimesTenClassic object are not exported or exposed.

Here is a code snippet showing how to set the value of the `.spec.ttspec.prometheus.publish` datum to `false` in a TimesTenClassic object YAML manifest file:

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: sample
spec:
  ttspec:
…
    prometheus:
      publish: false
```

In this example, the TimesTen Operator does not provision an `exporter` container for the `sample` TimesTenClassic object.

The default value for the `.spec.ttspec.prometheus.publish` datum is `true`. If you want the TimesTen Operator to provision an `exporter` container, you can choose the default or you can specify a value of `true` for the `.spec.ttspec.prometheus.publish` datum.

If you do not specify the `publish` datum, and any other datum is specified in the `.spec.ttspec.prometheus` clause, the default value for the `publish` datum is `true`.

If you do not specify the `.spec.ttspec.prometheus` clause and the TimesTen release is 22.1 or greater, the default value for the `publish` datum is dependent on the value of the `EXPOSE_METRICS` TimesTen Operator environment variable:

- If `EXPOSE_METRICS` is `"1"` (or not specified), the TimesTen Operator treats the `publish` datum as `true`.
- If `EXPOSE_METRICS` is `"0"`, the TimesTen Operator treats the `publish` datum as `false`.

For more information about the `.spec.ttspec.prometheus` clause of a TimesTenClassic object, see TimesTenClassicSpecSpecPrometheus.

For information about TimesTen Operator environment variables, see TimesTen Kubernetes Operator Environment Variables.

We recommend that you let the TimesTen Operator automatically export, expose, and publish TimesTen metrics. For a complete example, see Expose TimesTen Metrics Automatically.

Expose TimesTen Metrics Automatically

Let's walk through an example showing how the TimesTen Operator automatically exports and exposes TimesTen metrics. In this example, let's create a TimesTenClassic object and observe how the TimesTen Operator automatically creates the objects needed to automatically export and expose TimesTen metrics to Prometheus.

Let's assume you have installed the Prometheus Operator in your Kubernetes cluster and there is a Prometheus server running in your namespace. Let's also assume you have started the TimesTen Operator following the steps in About the TimesTen Operator and there are no TimesTenClassic objects deployed in your namespace.

1. Create a TimesTenClassic object.

   ```
   vi samplepublish.yaml

   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   metadata:
     name: samplepublish
   spec:
     ttspec:
       storageClassName: oci
       storageSize: 250G
       image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
       imagePullSecret: sekret
       prometheus:
         port: 6666
   ```

   In this example, the port on which the TimesTen exporter listens is `6666`.

2. Deploy the TimesTenClassic object.

   ```
   kubectl create -f samplepublish.yaml
   ```

   The output is the following:

   ```
   timestenclassic.timesten.oracle.com/samplepublish created
   ```

3. Wait a few minutes, then confirm the TimesTenClassic object is in the `Normal` state.

   ```
   kubectl get ttc samplepublish
   ```

   The output is similar to the following:

   ```
   NAME            STATE    ACTIVE            AGE
   samplepublish   Normal   samplepublish-0   3m56s
   ```

4. Confirm the TimesTen Operator provisioned an `exporter` container in each TimesTen Pod

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                  READY   STATUS    RESTARTS   AGE
   ...
   samplepublish-0                       3/3     Running   0          7m33s
   samplepublish-1                       3/3     Running   0          7m33s
   ...
   ```

   The TimesTen Operator automatically provisioned 3 containers in each TimesTen Pod. One of these containers is the `exporter` container, which is running the TimesTen exporter.

5. Confirm the TimesTen Operator automatically created the appropriate Kubernetes Secrets.

   ```
   kubectl get secrets
   ```

   The output is similar to the following:

   ```
   NAME
   TYPE                              DATA   AGE
   ...
   samplepublish-metrics
   Opaque                            1      15m
   samplepublish-metrics-client
   Opaque                            3      15m
   ```

   By default, TimesTen metrics are served using https. As a result, the TimesTen Operator automatically created an Oracle Wallet, the certificates, and the Kubernetes Secrets needed for https. For more information, see About Transport Layer Security (mutual TLS) Certificates for TimesTen Metrics.

6. Confirm the appropriate files are in the `samplepublish-metrics-client` Kubernetes Secret.

   ```
   kubectl describe secret samplepublish-metrics-client
   ```

   The output is similar to the following:

   ```
   Name:         samplepublish-metrics-client
   Namespace:    mynamespace
   Labels:       <none>
   ```

```
Annotations:  <none>

Type:  Opaque

Data
====
ca.crt:      1461 bytes
client.crt:  1273 bytes
client.key:  1675 bytes
```

The TimesTen Operator automatically created the `ca.crt`, `client.crt`, and `client.key` files. The `samplepublish-metrics-client` Kubernetes Secret holds these files. See About Transport Layer Security (mutual TLS) Certificates for TimesTen Metrics.

7. Confirm the TimesTen Operator automatically created the `samplepublish` PodMonitor object.

```
kubectl describe podmonitor samplepublish
```

The output is similar to the following:

```
Name:         samplepublish
Namespace:    mynamespace
Labels:       app=samplepublish
              database.timesten.oracle.com=samplepublish
Annotations:  <none>
API Version:  monitoring.coreos.com/v1
Kind:         PodMonitor
Metadata:
  Creation Timestamp:  2025-01-25T15:36:08Z
  Generation:          1
  Owner References:
    API Version:           timesten.oracle.com/v4
    Block Owner Deletion:  true
    Controller:            true
    Kind:                  TimesTenClassic
    Name:                  samplepublish
    UID:                   d0f46bf7-b1d8-4499-876c-51410a469772
  Resource Version:        284346942
  UID:                     5a61ec9e-df7d-4a98-be47-dce1e7c3d217
Spec:
  Namespace Selector:
  Pod Metrics Endpoints:
    Bearer Token Secret:
      Key:
    Interval:  15s
    Path:      /metrics
    Port:      exporter
    Scheme:    https
    Tls Config:
      Ca:
        Secret:
          Key:   ca.crt
          Name:  samplepublish-metrics-client
      Cert:
          Secret:
            Key:    client.crt
            Name:   samplepublish-metrics-client
        Key Secret:
          Key:         client.key
          Name:        samplepublish-metrics-client
        Server Name:
samplepublish.samplepublish.mynamespace.svc.cluster.local
  Selector:
    Match Labels:
      database.timesten.oracle.com:  samplepublish
Events:                              <none>
```

Let's look at the important information in this PodMonitor object:

- There is an `app=samplepublish` label. If there are Pods with a label that matches `app=samplepublish`, Prometheus scrapes metrics from them. The TimesTen Pods contain the `app=samplepublish` label. Prometheus will therefore scrape metrics from these Pods. We will see this later.
- Prometheus scrapes metrics from the `/metrics` endpoint.
- Metrics are exposed using https.
- The TimesTen Operator placed the `samplepublish-metrics` and `samplepublish-metrics-client` Kubernetes Secrets in the PodMonitor object. These Secrets and their contents are used by the Prometheus Operator.

The Prometheus Operator edits the Prometheus server configuration files based on the information in this PodMonitor object.

8. Confirm the TimesTen Operator automatically created the appropriate Kubernetes Service.

```
kubectl describe service samplepublish
```

The output is similar to the following:

```
Name:              samplepublish
Namespace:         mynamespace
Labels:            app=samplepublish
Annotations:       <none>
Selector:          app=samplepublish
Type:              ClusterIP
IP Family Policy:  SingleStack
IP Families:       IPv4
IP:                None
IPs:               None
Port:              cs  6625/TCP
TargetPort:        6625/TCP
Endpoints:         10.244.0.120:6625,10.244.1.144:6625
Port:              exporter  6666/TCP
TargetPort:        6666/TCP
Endpoints:         10.244.0.120:6666,10.244.1.144:6666
Session Affinity:  None
Events:            <none>
```

The TimesTen exporter listens on port `6666`.

9. Confirm there is a Prometheus server running in your namespace.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                              READY   STATUS    RESTARTS   AGE
prometheus-sampleprometheusserver-0   2/2     Running   2          18d
...
```

The `prometheus-sampleprometheusserver-0` Prometheus server is running in your namespace.

10. Confirm the Prometheus Operator edited the Prometheus server configuration file based on the information in the `samplepublish` PodMonitor object.

```
 kubectl exec prometheus-sampleprometheusserver-0 -c prometheus --
cat /etc/prometheus/config_out/prometheus.env.yaml
```

The output is similar to the following:

```
global:
  evaluation_interval: 30s
  scrape_interval: 30s
  external_labels:
    prometheus: mynamespace/sampleprometheusserver
    prometheus_replica: prometheus-sampleprometheusserver-0
scrape_configs:
- job_name: podMonitor/mynamespace/samplepublish/0
  honor_labels: false
  kubernetes_sd_configs:
  - role: pod
    namespaces:
      names:
      - mynamespace
  scrape_interval: 15s
  metrics_path: /metrics
  scheme: https
  tls_config:
    insecure_skip_verify: false
    ca_file: /etc/prometheus/certs/secret_mynamespace_samplepublish-
metrics-client_ca.crt
    cert_file: /etc/prometheus/certs/secret_mynamespace_samplepublish-
metrics-client_client.crt
    key_file: /etc/prometheus/certs/secret_mynamespace_samplepublish-
metrics-client_client.key
    server_name: samplepublish.samplepublish.mynamespace.svc.cluster.local
  relabel_configs:
  - source_labels:
    - job
    target_label: __tmp_prometheus_job_name
  - action: drop
    source_labels:
    - __meta_kubernetes_pod_phase
```

```
          regex: (Failed|Succeeded)
        - action: keep
          source_labels:
          - __meta_kubernetes_pod_label_database_timesten_oracle_com
          - __meta_kubernetes_pod_labelpresent_database_timesten_oracle_com
          regex: (samplepublish);true
        - action: keep
          source_labels:
          - __meta_kubernetes_pod_container_port_name
          regex: exporter
        - source_labels:
          - __meta_kubernetes_namespace
          target_label: namespace
        - source_labels:
          - __meta_kubernetes_pod_container_name
          target_label: container
        - source_labels:
          - __meta_kubernetes_pod_name
          target_label: pod
        - target_label: job
          replacement: mynamespace/samplepublish
        - target_label: endpoint
          replacement: exporter
        - source_labels:
          - __address__
          target_label: __tmp_hash
          modulus: 1
          action: hashmod
        - source_labels:
          - __tmp_hash
          regex: 0
          action: keep
        metric_relabel_configs: []
```

Prometheus has the information it needs to scrape TimesTen metrics.

11. Review some of the TimesTen metrics: In your browser, go to your Prometheus server.
    a. In the Prometheus server search bar, type a TimesTen metric. For example, **timesten_databases**. Next, click **Execute**.

       The output is similar to the following:

```
timesten_databases{container="exporter", endpoint="exporter",
instance="10.244.0.120:6666", instancename="instance1",
job="mynamespace/samplepublish",
namespace="mynamespace", pod="samplepublish-0"} 1

timesten_databases{container="exporter", endpoint="exporter",
instance="10.244.1.144:6666", instancename="instance1",
job="mynamespace/samplepublish",
namespace="mynamespace", pod="samplepublish-1"} 1
```

       There is one TimesTen database in the `samplepublish-0` Pod and one TimesTen database in the `samplepublish-1` Pod as evidenced by the value of **1** for the metric.

b. In the Prometheus server search bar, type a second TimesTen metric. For example, **timesten_database_loaded**. Next, click **Execute**.

   The output is similar to the following:

```
timesten_database_loaded{container="exporter", dsn="samplepublish",
endpoint="exporter", instance="10.244.0.120:6666",
instancename="instance1",
job="mynamespace/samplepublish", namespace="mynamespace",
pod="samplepublish-0"} 1

timesten_database_loaded{container="exporter", dsn="samplepublish",
endpoint="exporter", instance="10.244.1.144:6666",
instancename="instance1",
job="mynamespace/samplepublish", namespace="mynamespace",
pod="samplepublish-1"} 1
```

   The `samplepublish` database in the `samplepublish-0` Pod and the `samplepublish` database in the `samplepublish-1` Pod are both loaded into memory as evidenced by the value of **1** for the metric.

Congratulations! You successfully created TimesTen databases whose metrics are collected by Prometheus.

13

Expose Metrics from the TimesTen Kubernetes Operator

The TimesTen Kubernetes Operator (TimesTen Operator) can expose metrics about its own functionality as well as the status of TimesTenClassic objects to Prometheus or any other scraping mechanism.

This chapter shows you how.

Topics:

About Exposing Metrics from the TimesTen Kubernetes Operator

By default, the TimesTen Kubernetes Operator exposes metrics about its own functionality as well as the status of TimesTenClassic objects it manages.

Let's look at how the TimesTen Operator does this. Let's examine the default behavior and let's determine how you can change the default behavior if you choose to do so.

By default, the TimesTen Operator does the following:

- Exports and exposes metrics about its own functionality and the overall status of the TimesTenClassic objects that it manages.
- Uses https/Transport Layer Security (mutual TLS) to make these metrics available.
- Automatically creates certificates, Oracle Wallets, and Kubernetes Secrets required for TLS.
- If the Prometheus Operator is installed, creates the appropriate objects to cause Prometheus to be automatically modified, which then causes Prometheus to scrape metrics from the TimesTen Operator.
- Exposes metrics outside of the TimesTen Operator Pods.

Although this default behavior is recommended, you have the option of changing the default behavior. Let's examine our options:

- https or http?: TimesTen Operator metrics are available by https (default) or http.
- Create a Kubernetes ServiceMonitor object?: If the Prometheus Operator is installed in your Kubernetes cluster, the TimesTen Operator can create a Kubernetes ServiceMonitor object. This object contains the information needed by the Prometheus Operator to

configure the TimesTen Operator as a scrape target. If the Prometheus Operator has been installed in your Kubernetes cluster, then by default the TimesTen Operator creates a ServiceMonitor object.

- Expose TimesTen Operator metrics outside of the TimesTen Operator Pods?: The TimesTen Operator listens on and accepts GETs on the `timesten-operator.`*`mynamespace`*`.svc.cluster.local:8080/metrics` endpoint (where *`mynamespace`* is the name of your namespace). By default, the TimesTen Operator deploys a Kubernetes Service that makes this endpoint available to other Pods in the Kubernetes cluster. You can choose not to create this Service.

Now, let's look at how we can change the default behavior.

The TimesTen Operator is deployed as a Kubernetes Deployment. The provided `operator.yaml` and `cluster_operator.yaml` YAML manifest file that lets you customize this Deployment. These files are located in the `deploy` directory of the TimesTen Operator distribution. For more information, see About the TimesTen Operator.

The `operator.yaml` file contains various environment variables. Three of these variables govern if and how the TimesTen Operator exports and exposes metrics about its own operation and the status of the TimesTenClassic objects that it manages.

- `METRICS_SCHEME`: Determines if metrics should be made available by https or http. A setting of `"https"` (default) indicates https should be used. A setting of `"http"` indicates http should be used.
- `CREATE_SERVICEMONITOR`: Determines if the TimesTen Operator should create a Kubernetes ServiceMonitor object (discussed in a later section). A setting of `"1"` (default) indicates the TimesTen Operator should create a ServiceMonitor object. A setting of `"0"` indicates the TimesTen Operator should not create a ServiceMonitor object.
- `EXPOSE_METRICS`: Determines if metrics are exposed outside of the TimesTen Operator Pods. A setting of `"1"` (default) indicates metrics should be exposed outside of the TimesTen Operator Pods. A setting of `"0"` indicates metrics should not be exposed outside of the TimesTen Operator Pods.

Let's look at a snippet of an `operator.yaml` file that shows the existence of these environment variables and the default settings.

```
# Copyright (c) 2019 - 2025, Oracle and/or its affiliates.
apiVersion: apps/v1
kind: Deployment
metadata:
  name: timesten-operator
spec:
...
          env:
            ...
            - name: EXPOSE_METRICS
              value: "1"
            - name: METRICS_SCHEME
              value: "https"
            - name: EXPOSE_PROBES
              value: "1"
            - name: CREATE_SERVICEMONITOR
              value: "1"
...
```

For reference information about these variables, see TimesTen Kubernetes Operator Environment Variables.

> **Note**
>
> TimesTen Operator metrics are accurate when you have one TimesTen Operator defined in your TimesTen Operator Deployment (`replicas:1` in your `operator.yaml` file).

About Using http or https

TimesTen Operator metrics are available by http or https.

The default behavior is https. To cause the TimesTen Operator to use http instead of https, set the `METRICS_SCHEME` environment variable to `"http"` in your `operator.yaml` YAML manifest file.

> **Note**
>
> In TimesTen release 18.1, if you specify https for the `METRICS_SCHEME` environment variable, the TimesTen Operator acts as though you specified http.

About Transport Layer Security (mutual TLS) Certificates

When https is used, the TimesTen Operator automatically creates self-signed certificates. The TimesTen Operator also creates two Kubernetes Secrets to hold these certificates:

- `timesten-operator-metrics`: This Secret is used internally by the TimesTen Operator. It contains all the certificates needed by the TimesTen Kubernetes Operator for https/TLS. You do not need to use or examine this Secret.
- `timesten-operator-metrics-client`: This Secret contains files that a Prometheus server (or other scraper) requires to scrape metrics from the TimesTen Operator. This Secret contains the following three files:
  - `ca.crt`: The Certificate Authority certificate needed by the client to authenticate the self-signed certificate used by the TimesTen Operator.
  - `client.crt`: The client certificate that the TimesTen Operator uses to authenticate any clients that try to scrape metrics from it.
  - `client.key`: The private key that is associated with the `client.crt` client certificate.

Both Secrets are created with appropriate Kubernetes owner references. If you delete the TimesTen Operator deployment, these Secrets are automatically deleted.

> **Note**
>
> When http is used, these certificates, Wallets, and Secrets are not created.

About Creating ServiceMonitor Objects

By default, if the Prometheus Operator is installed in your Kubernetes cluster, the TimesTen Operator attempts to create a Kubernetes ServiceMonitor object called `timesten-operator`. This object includes the information needed by Prometheus to configure the TimesTen Operator as a scrape target. If installed in your cluster, the Prometheus Operator responds to the creation of this object by editing the Prometheus configuration files to scrape metrics from the corresponding Service. For more information about ServiceMonitor objects, see https://prometheus-operator.dev/docs/getting-started/design/#servicemonitor.

A ServiceMonitor object created by the TimesTen Operator has an owner reference to the appropriate TimesTen Operator deployment. This ensures that the ServiceMonitor object is automatically deleted if the TimesTen Operator deployment is deleted.

The `CREATE_SERVICEMONITOR` environment variable determines if the TimesTen Operator creates a ServiceMonitor object. If you do not want the TimesTen Operator to create a ServiceMonitor object, then set `CREATE_SERVICEMONITOR` to `"0"` in your `operator.yaml` YAML manifest file..

About the TimesTen Kubernetes Operator's Metrics Service

The TimesTen Operator always makes metrics available. However, you can limit access to the TimesTen Operator's `/metrics` endpoint. By default, the TimesTen Operator's `/metrics` endpoint is available to other Pods in the Kubernetes cluster. Specifically, the TimesTen Operator automatically creates a Kubernetes Service called `timesten-operator`. This Service exposes the metrics port in the active TimesTen Operator Pod to the rest of the cluster at `timesten-operator.`*`mynamespace`*`.svc.cluster.local:8080/metrics` (where *`mynamespace`* is the name of your namespace).

If you choose not to expose TimesTen Operator metrics outside of the TimesTen Operator's Pods, set the `EXPOSE_METRICS` environment variable to `"0"` in your `operator.yaml` YAML manifest file. In this case, the metrics port is not exposed by a Kubernetes Service. (You could still fetch metrics by using the `kubectl exec` command to run `curl` or a similar tool within the TimesTen Operator Pod itself.)

If you set the `EXPOSE_METRICS` environment variable to `"0"` and the `CREATE_SERVICEMONITOR` environment variable is set to `"1"` (default), the `CREATE_SERVICEMONITOR` environment variable is treated as though it was set to `"0"`.

In addition, if you set the `EXPOSE_METRICS` environment variable to `"0"`, the value of the `METRICS_SCHEME` environment variable is ignored and http is always used.

About TimesTen Operator Metrics

The TimesTen Operator publishes metrics about its own functionality as well as the status of TimesTenClassic objects that it manages.

For details about the metrics, see TimesTen Kubernetes Operator Metrics.

Demonstrate How to Expose TimesTen Kubernetes Operator Metrics

Let's walk through an example illustrating how the TimesTen Kubernetes Operator exposes metrics about its own functionality as well as the status of TimesTenClassic objects. Let's assume Prometheus is installed in your Kubernetes cluster and you have a Prometheus server running in your namespace.

Let's make the following decisions:

- https or http?: Let's choose https. The `METRICS_SCHEME` environment variable determines if metrics should be made available by https or http. A setting of `"1"` (default) indicates https.
- Create a ServiceMonitor object?: Let's have the TimesTen Operator create a ServiceMonitor object. This object contains the information needed by Prometheus to configure the TimesTen Operator as a scrape target. The `CREATE_SERVICEMONITOR` environment variable determines if the TimesTen Operator should create a ServiceMonitor object. A setting of `"1"` (default) indicates the TimesTen Operator should create the object.
- Expose TimesTen Operator metrics outside of the TimesTen Operator Pods?: Let's have the metrics exposed outside of the TimesTen Operator Pods so that Prometheus can scrape metrics from it. The `EXPOSE_METRICS` environment variable determines if metrics are exposed outside of the TimesTen Operator Pods. A setting of `"1"` (default) indicates metrics should be exposed. This means that the TimesTen Operator will create a Kubernetes Service (called `timesten-operator`) that allows the `/metrics` endpoint to be available to other Pods in the Kubernetes cluster.

Since we have chosen the defaults for the TimesTen Operator environment variables, you do not have to modify these variables in the `operator.yaml` YAML manifest file.

1. Start the TimesTen Operator following the steps in About the TimesTen Operator.
2. (Optional) Review the TimesTen Operator deployment running in your namespace.

   ```
   kubectl describe deployment timesten-operator
   ```

   Output.

   ```
   Name:                   timesten-operator
   Namespace:              mynamespace
   CreationTimestamp:      Thu, 16 Jan 2025 20:48:48 +0000
   Labels:                 <none>
   Annotations:            deployment.kubernetes.io/revision: 1
   Selector:               name=timesten-operator
   Replicas:               1 desired | 1 updated | 1 total | 1 available | 0
   unavailable
   StrategyType:           RollingUpdate
   MinReadySeconds:        0
   RollingUpdateStrategy:  25% max unavailable, 25% max surge
   Pod Template:
     Labels:           name=timesten-operator
     Service Account:  timesten-operator
     Containers:
      timesten-operator:
       Image:      container-registry.oracle.com/timesten/timesten:26.1.1.1.0
   ```

```
    Ports:       8081/TCP, 8080/TCP
    Host Ports:  0/TCP, 0/TCP
    Command:
      /timesten/operator/operator/timesten-operator
    Liveness:   http-get http://:probes/healthz delay=10s timeout=10s
period=30s #success=1 #failure=3
    Readiness:  http-get http://:probes/healthz delay=10s timeout=10s
period=10s #success=1 #failure=1
    Environment:
      WATCH_NAMESPACE:         (v1:metadata.namespace)
      POD_NAME:                (v1:metadata.name)
      OPERATOR_NAME:          timesten-operator
      EXPOSE_METRICS:         1
      METRICS_SCHEME:         https
      EXPOSE_PROBES:          1
      CREATE_SERVICEMONITOR:  1
    Mounts:                   <none>
  Volumes:                    <none>
Conditions:
  Type           Status  Reason
  ----           ------  ------
  Available      True    MinimumReplicasAvailable
  Progressing    True    NewReplicaSetAvailable
OldReplicaSets:  <none>
NewReplicaSet:   timesten-operator-7f77c749fd (1/1 replicas created)
Events:
  Type    Reason             Age   From                   Message
  ----    ------             ----  ----                   -------
  Normal  ScalingReplicaSet  73s   deployment-controller  Scaled up
replica set timesten-operator-7f77c749fd to 1
```

The `EXPOSE_METRICS` and `CREATE_SERVICEMONITOR` TimesTen Operator environment variables are set to `1` (defaults) and the `METRICS_SCHEME` is set to `https` (default).

3. Confirm the TimesTen Operator created the appropriate Kubernetes Secrets.

```
 kubectl get secrets
```

Output:

```
NAME
TYPE                             DATA   AGE
...
timesten-operator-metrics
Opaque                           1      11m
timesten-operator-metrics-client
Opaque                           3      11m
```

The TimesTen Operator created the `timesten-operator-metrics` Kubernetes Secret. This Secret contains the certificates needed by the TimesTen Operator for https/TLS. This Secret is used internally by the TimesTen Operator.

The TimesTen Operator also created the `timesten-operator-metrics-client` Kubernetes Secret. This Secret contains the files that a Prometheus server needs to scrape metrics from the TimesTen Operator Pods.

4. Confirm the appropriate files are in the `timesten-operator-metrics-client` Kubernetes Secret.

   ```
   kubectl describe secret timesten-operator-metrics-client
   ```

   Output:

   ```
   Name:         timesten-operator-metrics-client
   Namespace:    mynamespace
   Labels:       <none>
   Annotations:  <none>

   Type:  Opaque

   Data
   ====
   ca.crt:      1465 bytes
   client.crt:  1277 bytes
   client.key:  1675 bytes
   ```

   The Secret contains the following files:

   - `ca.crt`: The Certificate Authority file needed by the client to authenticate the self-signed certificate used by the TimesTen Operator.
   - `client.crt`: The client certificate that the TimesTen Operator uses to authenticate clients that are attempting to scrape metrics from it.
   - `client.key`: The private key that is associated with the client.crt file.

5. Confirm the TimesTen Operator created the `timesten-operator` ServiceMonitor object.

   ```
   kubectl describe servicemonitor timesten-operator
   ```

   Output:

   ```
   Name:         timesten-operator
   Namespace:    mynamespace
   Labels:       app=timesten-operator
                 database.timesten.oracle.com=timesten-operator
   Annotations:  deployment.kubernetes.io/revision: 1
   API Version:  monitoring.coreos.com/v1
   Kind:         ServiceMonitor
   Metadata:
     Creation Timestamp:  2025-01-24T20:49:33Z
     Generation:          1
     Owner References:
       API Version:           apps/v1
       Block Owner Deletion:  true
       Controller:            true
       Kind:                  Deployment
       Name:                  timesten-operator
       UID:                   3084af2d-90ca-49d1-874a-cde1174f50b5
     Resource Version:        282625424
     UID:                     6337b813-9d62-43b0-8594-60e387e7a30d
   Spec:
   ```

```
  Endpoints:
    Bearer Token Secret:
      Key:
    Interval:  15s
    Path:      /metrics
    Port:      metrics
    Scheme:    https
    Tls Config:
      Ca:
        Secret:
          Key:   ca.crt
          Name:  timesten-operator-metrics-client
      Cert:
        Secret:
          Key:   client.crt
          Name:  timesten-operator-metrics-client
      Key Secret:
        Key:         client.key
        Name:        timesten-operator-metrics-client
      Server Name:  timesten-operator.mynamespace.svc.cluster.local
  Namespace Selector:
  Selector:
    Match Labels:
      App:  timesten-operator
Events:      <none>
```

Let's look at the important information in this ServiceMonitor object:

- There is an `app=timesten-operator` label. If there are Pods with a label that matches `app=timesten-operator`, Prometheus scrapes metrics from them. The TimesTen Operator Pod contains the `app=timesten-operator` label. Prometheus will therefore scrape metrics from it. We will see this later.
- Prometheus scrapes metrics from the `/metrics` endpoint.
- Metrics are exposed using https.
- The TimesTen Operator placed the `timesten-operator-metrics` and `timesten-operator-metrics-client` Kubernetes Secrets in the ServiceMonitor object. These Secrets are used by the Prometheus Operator.

The Prometheus Operator edits the Prometheus server configuration files based on the information in this ServiceMonitor object.

6. Confirm the TimesTen Operator created the appropriate Kubernetes Service.

```
kubectl describe service timesten-operator
```

Output:

```
Name:              timesten-operator
Namespace:         mynamespace
Labels:            app=timesten-operator
                   database.timesten.oracle.com=timesten-operator
Annotations:       deployment.kubernetes.io/revision: 1
Selector:          name=timesten-operator
Type:              ClusterIP
IP Family Policy:  SingleStack
IP Families:       IPv4
IP:                10.96.169.59
IPs:               10.96.169.59
Port:              metrics  8080/TCP
TargetPort:        8080/TCP
Endpoints:         10.244.8.180:8080
Port:              probe  8081/TCP
TargetPort:        8081/TCP
Endpoints:         10.244.8.180:8081
Session Affinity:  None
Events:            <none>
```

7. Confirm there is a Prometheus server running in your namespace.

   ```
   kubectl get pods
   ```

   Output.

   ```
   NAME                                  READY   STATUS    RESTARTS   AGE
   prometheus-sampleprometheusserver-0   2/2     Running   0          10d
   ...
   ```

   The `prometheus-sampleprometheusserver-0` Prometheus server is running in your namespace.

8. Confirm the Prometheus Operator edited the Prometheus server configuration file based on the information in the `timesten-operator` ServiceMonitor object.

   ```
    kubectl exec prometheus-sampleprometheusserver-0 -c prometheus --
   cat /etc/prometheus/config_out/prometheus.env.yaml
   ```

   Output.

   ```
   global:
     evaluation_interval: 30s
     scrape_interval: 30s
     external_labels:
       prometheus: mynamespace/sampleprometheusserver
       prometheus_replica: prometheus-sampleprometheusserver-0
   scrape_configs:
   - job_name: serviceMonitor/mynamespace/timesten-operator/0
     honor_labels: false
     kubernetes_sd_configs:
     - role: endpoints
       namespaces:
         names:
         - mynamespace
     scrape_interval: 15s
     metrics_path: /metrics
     scheme: https
     tls_config:
       insecure_skip_verify: false
       ca_file: /etc/prometheus/certs/secret_mynamespace_timesten-operator-
   metrics-client_ca.crt
   ```

```
    cert_file: /etc/prometheus/certs/secret_mynamespace_timesten-operator-
metrics-client_client.crt
    key_file: /etc/prometheus/certs/secret_mynamespace_timesten-operator-
metrics-client_client.key
    server_name: timesten-operator.mynamespace.svc.cluster.local
  relabel_configs:
  - source_labels:
    - job
    target_label: __tmp_prometheus_job_name
  - action: keep
    source_labels:
    - __meta_kubernetes_service_label_app
    - __meta_kubernetes_service_labelpresent_app
    regex: (timesten-operator);true
  - action: keep
    source_labels:
    - __meta_kubernetes_endpoint_port_name
    regex: metrics
  - source_labels:
    - __meta_kubernetes_endpoint_address_target_kind
    - __meta_kubernetes_endpoint_address_target_name
    separator: ;
    regex: Node;(.*)
    replacement: ${1}
    target_label: node
  - source_labels:
    - __meta_kubernetes_endpoint_address_target_kind
    - __meta_kubernetes_endpoint_address_target_name
    separator: ;
    regex: Pod;(.*)
    replacement: ${1}
    target_label: pod
  - source_labels:
    - __meta_kubernetes_namespace
    target_label: namespace
  - source_labels:
    - __meta_kubernetes_service_name
    target_label: service
  - source_labels:
    - __meta_kubernetes_pod_name
    target_label: pod
  - source_labels:
    - __meta_kubernetes_pod_container_name
    target_label: container
  - action: drop
    source_labels:
    - __meta_kubernetes_pod_phase
    regex: (Failed|Succeeded)
  - source_labels:
    - __meta_kubernetes_service_name
    target_label: job
    replacement: ${1}
  - target_label: endpoint
    replacement: metrics
  - source_labels:
    - __address__
    target_label: __tmp_hash
    modulus: 1
    action: hashmod
  - source_labels:
    - __tmp_hash
    regex: 0
    action: keep
  metric_relabel_configs: []
```

Prometheus has the information it needs to scrape TimesTen Operator metrics.

9. Review then deploy a TimesTenClassic object.

   Review.

   ```
   cat sample.yaml
   ```

   Output.

   ```
   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   metadata:
     name: sample
   spec:
     ttspec:
       storageClassName: oci
       storageSize: 250G
       image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
       imagePullSecret: sekret
   ```

   Deploy:

   ```
   kubectl create -f sample.yaml
   ```

   Output:

   ```
   timestenclassic.timesten.oracle.com/sample created
   ```

10. Wait a few minutes, then confirm the `sample` TimesTenClassic object is in the `Normal` state.

    ```
    kubectl get ttc sample
    ```

    Output:

    ```
    NAME     STATE    ACTIVE     AGE
    sample   Normal   sample-0   2m37s
    ```

11. Review some of the TimesTen Operator metrics. In your browser, go to your Prometheus server.

    a. In the Prometheus server search bar, type a TimesTen Operator metric. For example, **timesten_classic_state_normal**. Next, click **Execute**.

Output.

```
timesten_classic_state_normal{container="timesten-operator",
endpoint="metrics", instance="10.244.8.180:8080", job="timesten-
operator",
name="sample", namespace="mynamespace", pod="timesten-
operator-7f77c749fd-2lt5x",
service="timesten-operator"} 1
```

There is one TimesTenClassic object (`sample`) and it is in the `Normal` state.

b. In the Prometheus server search bar, type a second TimesTen Operator metric. For example, **timesten_classic_state_not_normal**. Next, click **Execute**.

Output.

```
timesten_classic_state_not_normal{container="timesten-operator",
endpoint="metrics", instance="10.244.8.180:8080", job="timesten-
operator",
name="sample", namespace="mynamespace", pod="timesten-
operator-7f77c749fd-2lt5x",
service="timesten-operator"} 0
```

There is one TimesTenClassic object (`sample`) and it is in either `Normal` or `Initializing` state. A value of `0` indicates it is not in any other state.

c. In the Prometheus server search bar, type a third TimesTen Operator metric. For example, **timesten_classic_state**. Next, click **Execute**.

Output.

```
timesten_classic_state{container="timesten-operator",
endpoint="metrics",
instance="10.244.8.180:8080", job="timesten-operator", name="sample",
namespace="mynamespace", pod="timesten-operator-7f77c749fd-2lt5x",
service="timesten-operator", state="Initializing"} 0


timesten_classic_state{container="timesten-operator",
endpoint="metrics",
instance="10.244.8.180:8080", job="timesten-operator", name="sample",
namespace="mynamespace", pod="timesten-operator-7f77c749fd-2lt5x",
service="timesten-operator", state="Normal"} 1
```

The `sample` TimesTenClassic object is no longer in the `Initializing` state. It is now in the `Normal` state.

Congratulations! You successfully walked through an example demonstrating how TimesTen Operator metrics are exposed, scraped, and published.

14

Work with TimesTen Cache

The TimesTen Operator supports the use of TimesTen Cache in your Kubernetes environment.

About Using TimesTen Cache

The TimesTen Operator provides interfaces that you can use to configure cache groups.

These are the cache-related metadata files that you can provide:

- `cacheUser`: This file contains the TimesTen cache manager user. Its format is `user/ttpwd/orapwd`, containing the username, TimesTen password, and Oracle password for the user. The Oracle user (called the cache administration user in Oracle Database) must exist prior to creating and deploying TimesTen. The Operator creates the TimesTen user in the the TimesTen database with the given name and password. The Operator also grants this user the appropriate privileges.

  Here is an example:

  ```
  cachemanageruser/ttmgrpwd/oramgrpwd
  ```

  See cacheUser for more information.

- `cachegroups.sql`: This file may contain `CREATE CACHE GROUP` statements as well as `LOAD CACHE GROUP` statements for the Operator to automatically run when the TimesTen database is created. The file also contains TimesTen built-in procedures to update statistics on the cache group tables (such as, `ttOptEstimateStats` and `ttOptUpdateStats`).

  Here is an example:

  ```
  CREATE READONLY CACHE GROUP readcache
  AUTOREFRESH
    INTERVAL 5 SECONDS
  FROM oratt.readtab (
    keyval NUMBER NOT NULL PRIMARY KEY,
    str VARCHAR2(32)
  );

  LOAD CACHE GROUP readcache COMMIT EVERY 256 ROWS;
  ```

  See cachegroups.sql for more information.

If you provide the `cacheUser` and `cachegroups.sql` files, the Operator uses them to provision TimesTen Cache when a new database is created.

The following metadata files are also relevant for TimesTen Cache:

- `tnsnames.ora`: This file is required. It defines Oracle Net Services that applications connect to. For TimesTen Cache, this file configures the connectivity between the TimesTen and the Oracle Database (from which data is being cached). In this context, TimesTen is the application that is the connection to the Oracle Database. See tnsnames.ora for details.

- `sqlnet.ora`: This file is optional. However, it may be necessary depending on your Oracle Database configuration. The file defines options for how client applications communicate with the Oracle Database. In this context, TimesTen is the application. The `tnsnames.ora` and `sqlnet.ora` files together define how an application communicates with the Oracle Database.

  See sqlnet.ora for details.
- `db.ini`: This file is required. Its contents contain TimesTen connection attributes for your TimesTen database. The files are included in TimesTen's `sys.odbc.ini` file in TimesTen Classic or in the database definition file (dbDef) in TimesTen Scaelout. You must specify the `OracleNetServiceName` and the `DatabaseCharacterSet` connection attributes in this file. The `DatabaseCharacterSet` value must match the value of the Oracle database character set value.

  See db.ini for details.
- `schema.sql`: This file may be required. In TimesTen Cache, one or more cache table users own the cache tables. If this cache table user is not the cache manager user, then you must specify the `schema.sql` file and in it include the schema user. You must also assign the appropriate privileges to this schema user. For example, if the `oratt` schema user was created in the Oracle Database, and this user is not the TimesTen cache manager user, you must create the TimesTen `oratt` user in this file.

  The instance administrator uses the `ttIsql` utility to run this file immediately after the database is created. This file is run before the Operator configures TimesTen Cache, so ensure there are no cache definitions in this file.

  See Create the Oracle Database Users for more information on the schema users in the Oracle Database. See schema.sql for details about the `schema.sql` file.

In TimesTen Classic, the contents of the `cachegroups.sql` file runs on the active database before it is duplicated to the standby. If there are autorefresh cache groups specified in the `cachegroups.sql` file, they are paused by the agent prior to duplicating the active database to the standby. After the duplication process completes, these autorefresh cache groups are re-enabled.

Once created and rolled out, the Operator does not monitor or manage TimesTen Cache. Specifically, the Operator does not monitor the health of the cache agents, nor does it take further action to start or stop them. In addition, the Operator does not verify that data is propagating correctly between the TimesTen database and the Oracle Database.

If you delete your TimesTenClassic object, the Operator automatically cleans up the Oracle Database metadata. If, however, you want to retain the Oracle Database metadata, specify the `cacheCleanUp` datum in your TimesTenClassic object definition and set its value to `false`. See `cacheCleanup` datum in TimesTenClassicSpecSpec.

For a complete example, see TimesTen Cache in TimesTen Classic Example.

15

Use Encryption for Data Transmission

TimesTen replication and TimesTen Client/Server support the use of Transport Layer Security (TLS) for communication between TimesTen instances.

This chapter details the process for configuring and using TLS in your Kubernetes environment. This enables encrypted data transmission between your replicated TimesTen databases and, if in a Client/Server environment, between your TimesTen client applications and your TimesTen Server (your TimesTen database).

Topics include:

- Create TLS Certificates for Replication and Client/Server
- Configure TLS for Replication
- Configure TLS for Client/Server

Create TLS Certificates for Replication and Client/Server

By default, TimesTen replication transmits data between your TimesTen databases unencrypted. In addition, in a TimesTen Client/Server environment, by default data is transmitted unencrypted between your application and your TimesTen database.

You can choose to enable encryption for replication and for Client/Server through the use of Transport Layer Security (TLS). TimesTen provides the `ttCreateCerts` utility to generate self-signed certificates for TLS. For more information on TLS certificates and wallets, see About Using Certificates with Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.

Note

Java must be installed on your development host in order for you to use the `ttCertsCreate` utility. The utility searches for Java according to the `JRE_HOME`, `JAVA_HOME`, and `PATH` settings.

The `ttCreateCerts` utility is located in the `/bin` directory of a TimesTen instance. The utility creates three wallets: `rootWallet`, `clientWallet`, and `serverWallet`.

From your Linux development host, perform these steps to create the certificates.

1. Navigate to the `bin` directory of the installation and run the `ttInstanceCreate` utility interactively to create an instance. Recall that the *`installation_dir`* directory was created when you unpacked the TimesTen distribution.

   You have to create a TimesTen instance as the `ttCreateCerts` utility is run from a TimesTen instance. For more information on the `ttInstanceCreate` utility, see ttInstanceCreate in the *Oracle TimesTen In-Memory Database Reference*.

   Create the instance directory (`/scratch/ttuser/instance_dir`, in this example), then run the `ttInstanceCreate` utility, supplying the `-name` and the `-location` parameters. This example uses `instance1` as the name of the instance and uses `/scratch/ttuser/instance_dir` as the location of the instance.

```
% mkdir /scratch/ttuser/instance_dir

% installation_dir/tt26.1.1.1.0/bin/ttInstanceCreate -name instance1
-location /scratch/ttuser/instance_dir
Creating instance in /scratch/ttuser/instance_dir/instance1 ...
INFO: Mapping files from the installation to /scratch/ttuser/
instance_dir/instance1/install

NOTE: The TimesTen daemon startup/shutdown scripts have not been installed.

The startup script is located here :
        '/scratch/ttuser/instance_dir/instance1/startup/tt_instance1'

Run the 'setuproot' script :
        /scratch/ttuser/instance_dir/instance1/bin/setuproot -install
This will move the TimesTen startup script into its appropriate location.

The 26.1 Release Notes are located here :
  'installation_dir/tt26.1.1.1.0/README.html'
```

2. Set the `TIMESTEN_HOME` environment variable. This variable must be set before you run the `ttCertsCreate` utility. From the `bin` directory of the instance, source the `ttenv.csh` or the `ttenv.sh` script.

   This example uses the `bash` Bourne-type shell. (Not all output is shown.)

   ```
   % . /scratch/ttuser/instance_dir/instance1/bin/ttenv.sh
   LD_LIBRARY_PATH set to
   ...
   PATH set to
   ...
   CLASSPATH set to
   TIMESTEN_HOME set to /scratch/ttuser/instance_dir/instance1
   ```

3. Run the `ttCreateCerts` utility from the `bin` directory of the instance. This example uses the `-verbose` qualifier to show detailed output. See Using TLS for Client/Server in TimesTen in the *Oracle TimesTen In-Memory Database Security Guide* for more information on the `ttCreateCerts` utility.

   The default wallet directory is `timesten_home/conf`, where `timesten_home` is the TimesTen instance home directory. This example uses this default wallet directory.

   ```
   % /scratch/ttuser/instance_dir/instance1/bin/ttCreateCerts -verbose
   Requested Certificates:
   User Certificates:
   Subject:        CN=server1,C=US
   Trusted Certificates:
   Subject:        CN=ecRoot,C=US
   Requested Certificates:
   User Certificates:
   Subject:        CN=client1,C=US
   Trusted Certificates:
   Subject:        CN=ecRoot,C=US
   ttCreateCerts : certificates created in /scratch/ttuser/instance_dir/
   instance1/conf
   ```

4. Review the wallet locations and the certificates (represented in **bold**). The `cwallet.sso` in the `serverWallet` directory is the file you will supply as the `replicationWallet` metadata file for replication and for the server in a Client/Server environment. The `cwallet.sso` in the `clientWallet` directory is the file you will use for the client in a Client/Server

environment. See "About Configuration Metadata Details" for information on the replicationWallet and the clientWallet metadata files. Also see Configure TLS for Replication and Configure TLS for Client/Server for information on using these metadata files.

(These cwallet.sso files are also represented in **bold**).

```
% ls $TIMESTEN_HOME/conf
client1.cert  root.cert   server1.cert  snmp.ini     sys.ttconnect.ini
clientWallet  rootWallet  serverWallet  sys.odbc.ini  timesten.conf

% ls $TIMESTEN_HOME/conf/*Wallet*
/scratch/ttuser/instance_dir/instance1/conf/clientWallet:
cwallet.sso  cwallet.sso.lck

/scratch/ttuser/instance_dir/instance1/conf/rootWallet:
cwallet.sso  cwallet.sso.lck

/scratch/ttuser/instance_dir/instance1/conf/serverWallet:
cwallet.sso  cwallet.sso.lck
```

You have successfully created the certificates that can be used for TLS for both replication and TimesTen Client/Server. You are now ready to configure and use TLS for replication, for Client/Server, or for both replication and Client/Server.

Configure TLS for Replication

You can configure TLS for replication to ensure secure network communication between your replicated TimesTen databases. See Transport Layer Security for TimesTen Replication in the *Oracle TimesTen In-Memory Database Security Guide* for detailed information.

These sections describe how to configure and use TLS for replication:

- Create Metadata Files and Kubernetes Facilities
- Create a TimesTenClassic Object
- Monitor Deployment of a TimesTenClassic Object
- Verify TLS Is Being Used for Replication

Create Metadata Files and Kubernetes Facilities

The /ttconfig/replicationWallet metadata file is required for TLS support for replication. (The /ttconfig directory is located in the containers of your TimesTen databases.) This file must contain the cwallet.sso file (the Oracle wallet) that was generated when you created the TLS certificates. Recall that this file was located in the /scratch/ttuser/instance_dir/instance1/conf/serverWallet directory. See Create TLS Certificates for Replication and Client/Server for information on creating these certificates. This wallet contains the credentials that are used by TimesTen replication for configuring TLS encryption between your active standby pair of TimesTen databases.

In addition to the /ttconfig/replicationWallet metadata file, you may use the other supported metadata files. See About Configuration Metadata Details for information on these supported metadata files.

You can include these metadata files in one or more Kubernetes facilities (for example, in a Kubernetes Secret, in a ConfigMap, or in an init container). This ensures the metadata files are populated in the /ttconfig directory of the TimesTen containers. Note that there is no requirement as to how to get the metadata files into this `/ttconfig` directory. See Populate the /ttconfig Directory for more information.

The example in the following sections illustrates how to include the `replicationWallet` metadata file in a Kubernetes Secret. It also creates the `db.ini`, the `adminUser`, and the `schema.sql` metadata files and includes these metadata files in a ConfigMap:

- Create a Kubernetes Secret
- Create a ConfigMap

Create a Kubernetes Secret

This section creates the `repl-tls` Kubernetes Secret. The `repl-tls` Secret will contain the `replicationWallet` metadata file.

On your Linux development host:

1. From the directory of your choice, create an empty subdirectory. This example creates the `serverWallet` subdirectory. (The `serverWallet` directory is used in the remainder of this example to denote this directory.)

   ```
   % mkdir -p serverWallet
   ```

2. Copy the `/scratch/ttuser/instance_dir/instance1/conf/serverWallet/cwallet.sso` file into the `serverWallet` directory that you just created. Recall that this file was generated when you used the `ttCreateCerts` utility to create the TLS certificates. See "Create TLS Certificates for Replication and Client/Server" for information.

   ```
   % cp /scratch/ttuser/instance_dir/instance1/conf/serverWallet/cwallet.sso
   serverWallet/cwallet.sso
   ```

3. Create the Kubernetes Secret.

   In this example:

   - The name of the Secret is `repl-tls`. Replace `repl-tls` with a name of your choosing. (`repl-tls` is represented in **bold**.)
   - The name of the metadata file required for TLS replication is `replicationWallet` (represented in **bold**).
   - The location of the wallet directory is `serverWallet` (in this example, represented in **bold**). If you use a different directory, replace `serverWallet` with the name of your directory.
   - The name of the Oracle wallet is `cwallet.sso` (represented in **bold**).

   Use the `kubectl create` command to create the Secret:

   ```
   % kubectl create secret generic repl-tls
   --from-file=replicationWallet=serverWallet/cwallet.sso
   secret/repl-tls created
   ```

You have successfully created and deployed the `repl-tls` Kubernetes Secret. The `replicationWallet/cwallet.sso` file will later be available in the `/ttconfig` directory of the TimesTen containers. In addition, the file will be available in the `/tt/home/timesten/replicationWallet` directory of the TimesTen containers.

Create a ConfigMap

This section creates the `repl-tls` ConfigMap. This ConfigMap contains the `db.ini`, the `adminUser`, and the `schema.sql` metadata files.

These metadata files are not required for TLS, but are included as additional attributes for your TimesTen databases. See "Overview of Configuration Metadata and Kubernetes Facilities" for information on the metadata files and the ConfigMap facility.

On your Linux development host:

1. From the directory of your choice, create an empty subdirectory for the metadata files. This example creates the `cm_replTLS` subdirectory. (The `cm_replTLS` directory is used in the remainder of this example to denote this directory.)

   ```
   % mkdir -p cm_replTLS
   ```

2. Navigate to the ConfigMap directory.

   ```
   % cd cm_replTLS
   ```

3. Create the `db.ini` file in this ConfigMap directory (`cm_replTLS`, in this example). In this `db.ini` file, define the `PermSize` and `DatabaseCharacterSet` connection attributes.

   ```
   vi db.ini

   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ```

4. Create the `adminUser` file in this ConfigMap directory (`cm_replTLS`, in this example). In this `adminUser` file, create the `sampleuser` user with the `samplepw` password.

   ```
   vi adminUser

   sampleuser/samplepw
   ```

5. Create the `schema.sql` file in this ConfigMap directory (`cm_replTLS`, in this example). In this `schema.sql` file, define the `s` sequence and the `emp` table for the `sampleuser` user. The Operator will automatically initialize your database with these object definitions.

   ```
   vi schema.sql

   create sequence sampleuser.s;
   create table sampleuser.emp (
     id number not null primary key,
     name char(32)
   );
   ```

6. Create the ConfigMap. The files in the `cm_replTLS` directory are included in the ConfigMap and, later, will be available in the TimesTen containers.

   In this example:

   - The name of the ConfigMap is `repl-tls`. Replace `repl-tls` with a name of your choosing. (`repl-tls` is represented in **bold** in this example.)
   - This example uses `cm_replTLS` as the directory where the files that will be copied into the ConfigMap reside. If you use a different directory, replace `cm_replTLS` with the name of your directory. (`cm_replTLS` is represented in **bold** in this example.)

   Use the `kubectl create` command to create the ConfigMap:

   ```
   % kubectl create configmap repl-tls --from-file=cm_replTLS
   configmap/repl-tls created
   ```

7. Use the `kubectl describe` command to verify the contents of the ConfigMap. (`repl-tls`, in this example.)

   ```
   % kubectl describe configmap repl-tls
   Name:         repl-tls
   Namespace:    mynamespace
   Labels:       <none>
   Annotations:  <none>

   Data
   ====
   adminUser:
   ----
   sampleuser/samplepw

   db.ini:
   ----
   PermSize=200
   DatabaseCharacterSet=AL32UTF8

   schema.sql:
   ----
   create sequence sampleuser.s;
   create table sampleuser.emp (id number not null primary key, name char (32));

   Events:  <none>
   ```

You have successfully created and deployed the `repl-tls` ConfigMap.

Create a TimesTenClassic Object

This section creates the TimesTenClassic object. For detailed information about the TimesTenClassic object type, see Syntax for the TimesTenClassic Object Type.

Perform these steps:

1. Create an empty YAML file. You can choose any name, but you may want to use the same name you used for the name of the TimesTenClassic object. (In this example, `repltls`.) The YAML file contains the definitions for the TimesTenClassic object. See "TimesTenClassicSpecSpec" for information on the fields that you must specify in this YAML file as well as the fields that are optional.

   In this example, the fields of particular interest for TLS replication are:

   - `dbSecret`: This example uses one Kubernetes Secret (called `repl-tls`) for the `replicationWallet` metadata file.
   - `replicationCipherSuite`: This field is required for TLS for replication. In this example, the value is `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256`. See Task 3: Configure TLS for Replication in the *Oracle TimesTen In-Memory Database Security Guide* and see the `replicationCipherSuite` entry in "Table 18-3" in this book for more information.
   - `replicationSSLMandatory`: This field is optional. In this example, set `replicationSSLMandatory` equal to 1. See Task 3: Configure TLS for Replication in the *Oracle TimesTen In-Memory Database Security Guide* and see the `replicationSSLMandatory` entry in Table 18-3 in this book for more information.

   In addition, this example includes:

   - `name`: Replace `repltls` with the name of your TimesTenClassic object.
   - `storageClassName`: Replace `oci-bv` with the name of the storage class used to allocate PersistentVolumes to hold TimesTen.

- `storageSize`: Replace `250Gi` with the amount of storage that should be requested for each Pod to hold TimesTen. Note: This example assumes a production environment and uses a value of `250Gi` for `storageSize`. For demonstration purposes, a value of `50Gi` is adequate. See the `storageSize` and the `logStorageSize` entries in "Table 18-3" for information.
- `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` with the location and the name of image.
- `imagePullSecret`: Replace `sekret` with the image pull secret that Kubernetes should use to fetch the TimesTen image.
- `dbConfigMap`: This example uses one ConfigMap (called `repl-tls`) for the `db.ini`, the `adminUser`, and the `schema.sql` metadata files.

```
% vi repltls.yaml

apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: repltls
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 250Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    dbConfigMap:
    - repl-tls
    dbSecret:
    - repl-tls
    replicationCipherSuite: SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
    replicationSSLMandatory: 1
```

2. Use the `kubectl create` command to create the TimesTenClassic object from the contents of the YAML file (in this example, `repltls.yaml`). Doing so begins the process of deploying your active standby pair of TimesTen databases in the Kubernetes cluster.

```
% kubectl create -f repltls.yaml
timestenclassic.timesten.oracle.com/repltls created
```

You have successfully created the TimesTenClassic object in the Kubernetes cluster. The process of deploying your TimesTen databases begins, but is not yet complete.

Monitor Deployment of a TimesTenClassic Object

Use the `kubectl get` and the `kubectl describe` commands to monitor the progress of the active standby pair as it is provisioned.

1. Use the `kubectl get` command and review the `STATE` field. Observe the value is `Initializing`. The active standby pair provisioning has begun, but is not yet complete.

```
% kubectl get ttc repltls
NAME      STATE          ACTIVE   AGE
repltls   Initializing   None     50s
```

2. Use the `kubectl get` command again to see if value of the `STATE` field has changed. In this example, the value is `Normal`, indicating the active standby pair of databases are now provisioned and the process is complete.

```
% kubectl get ttc repltls
NAME      STATE    ACTIVE      AGE
repltls   Normal   repltls-0   3m45s
```

3. Use the `kubectl describe` command to view the active standby pair provisioning in detail.

   Note the following have been correctly set in the `repltls` TimesTenClassic object definition:

   - The `repl-tls` Secret has been correctly referenced in the `dbSecret` field (represented in **bold**).
   - The `repl-tls` Configmap has been correctly referenced in the `dbConfigMap` field (represented in **bold**).
   - The `replicationCipherSuite` field has been correctly set to `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256` (represented in **bold**).
   - The `replicationSSLMandatory` field has been correctly set to `1` (represented in **bold**).

   Note: Not all of the output is shown in this example.

```
% kubectl describe ttc repltls
Name:         repltls
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>
API Version:  timesten.oracle.com/v4
Kind:         TimesTenClassic
Metadata:
  Creation Timestamp:  2025-01-16T18:51:43Z
  Generation:          1
  Resource Version:    75029797
  Self Link:
/apis/timesten.oracle.com/v4/namespaces/mynamespace/timestenclassics/repltls
  UID:                 a2915ef3-0fe0-11eb-8b9a-aaa0151611fe
Spec:
  Ttspec:
    Db Config Map:
      repl-tls
    Db Secret:
      repl-tls
    Image:                        container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
    Image Pull Policy:            Always
    Image Pull Secret:            sekret
    Replication Cipher Suite:     SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
    Replication SSL Mandatory:    1
    Storage Class Name:           oci-bv
    Storage Size:                 250Gi
...
Events:
  Type  Reason       Age    From       Message
  ----  ------       ----   ----       -------
  -     Create       4m17s  ttclassic  Secret tta2915ef3-0fe0-11eb-8b9a-aaa0151611fe
created
  -     Create       4m17s  ttclassic  Service repltls created
  -     Create       4m17s  ttclassic  StatefulSet repltls created
  -     StateChange  3m10s  ttclassic  Pod repltls-1 Agent Up
  -     StateChange  3m10s  ttclassic  Pod repltls-1 Release 26.1.1.1.0
  -     StateChange  3m10s  ttclassic  Pod repltls-1 Daemon Up
  -     StateChange  2m3s   ttclassic  Pod repltls-0 Agent Up
  -     StateChange  2m3s   ttclassic  Pod repltls-0 Release 26.1.1.1.0
  -     StateChange  2m1s   ttclassic  Pod repltls-0 Daemon Up
  -     StateChange  68s    ttclassic  Pod repltls-0 Database Loaded
  -     StateChange  68s    ttclassic  Pod repltls-0 Database Updatable
  -     StateChange  68s    ttclassic  Pod repltls-0 CacheAgent Not Running
  -     StateChange  68s    ttclassic  Pod repltls-0 RepAgent Not Running
  -     StateChange  67s    ttclassic  Pod repltls-0 RepState IDLE
  -     StateChange  67s    ttclassic  Pod repltls-0 RepScheme None
  -     StateChange  66s    ttclassic  Pod repltls-0 RepAgent Running
  -     StateChange  66s    ttclassic  Pod repltls-0 RepScheme Exists
  -     StateChange  66s    ttclassic  Pod repltls-0 RepState ACTIVE
  -     StateChange  47s    ttclassic  Pod repltls-1 Database Loaded
  -     StateChange  47s    ttclassic  Pod repltls-1 Database Not Updatable
  -     StateChange  47s    ttclassic  Pod repltls-1 CacheAgent Not Running
  -     StateChange  47s    ttclassic  Pod repltls-1 RepAgent Not Running
  -     StateChange  47s    ttclassic  Pod repltls-1 RepScheme Exists
  -     StateChange  47s    ttclassic  Pod repltls-1 RepState IDLE
  -     StateChange  41s    ttclassic  Pod repltls-1 RepAgent Running
  -     StateChange  36s    ttclassic  Pod repltls-1 RepState STANDBY
  -     StateChange  36s    ttclassic  TimesTenClassic was Initializing, now Normal
```

Your active standby pair of TimesTen databases are successfully deployed (as indicated by `Normal`.) You are now ready to verify that TLS is being used for replication.

Verify TLS Is Being Used for Replication

To verify TLS is being used for replication, perform the following steps:

1. Review the active (`repltls-0`, in this example) pod and the standby pod (`repltls-1`, in this example).

   ```
   % kubectl get pods
   NAME                                   READY   STATUS    RESTARTS   AGE
   repltls-0                              2/2     Running   0          6m35s
   repltls-1                              2/2     Running   0          6m34s
   timesten-operator-f84766548-tch7s      1/1     Running   0          28d
   ```

2. Optional: Use the `kubectl exec -it` command to invoke the shell in the active Pod (`repltls-0`, in this example).

   ```
   % kubectl exec -it repltls-0 -c tt -- /bin/bash
   ```

3. Optional: From the shell in the active pod, verify the `cwallet.sso` file is located in the `/tt/home/timesten/replicationWallet` directory.

   ```
   % ls /tt/home/timesten/replicationWallet
   cwallet.sso
   ```

4. Optional: From the shell in the active pod, verify that the TLS replication-specific values are correct in the `timesten.conf` configuration file. (This file is located in the `/tt/home/timesten/instances/instance1/conf` directory.)

   In particular, note that:

   - `replication_wallet` is correctly set to `/tt/home/timesten/replicationWallet` (represented in **bold**).
   - `replication_cipher_suite` is correctly set to `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256` (represented in **bold**).
   - `replication_ssl_mandatory` is correctly set to `1` (represented in **bold**).

   See Task 3: Configure TLS for Replication in the *Oracle TimesTen In-Memory Database Security Guide* for more information on these `timesten.conf` attributes.

   ```
   % cat /tt/home/timesten/instances/instance1/conf/timesten.conf
   admin_uid=3429
   admin_user=timesten
   daemon_port=6624
   ```

```
group_name=timesten
hostname=repltls-0
instance_guid=48AC5964-56A1-4C66-AB89-5646A2431EA3
instance_name=instance1
replication_cipher_suite=SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
replication_ssl_mandatory=1
replication_wallet=/tt/home/timesten/replicationWallet
server_port=6625
show_date=1
timesten_release=26.1.1
tns_admin=/ttconfig
verbose=1
```

5. From the shell in the active pod, run the `ttRepAdmin` utility with the `-showstatus -detail` options to verify the replication agent transmitters and receivers are using TLS (as indicated by SSL, represented in **bold**). See ttRepAdmin in the *Oracle TimesTen In-Memory Database Reference* for information on this utility.

   Note: Not all output is shown in this example.

   ```
   % ttRepAdmin -showstatus -detail repltls

   Replication Agent Status as of: 2025-01-16 19:01:55

   DSN                         : repltls
   ...
   TRANSMITTER thread(s) (TRANSMITTER(M):139870727366400):
    For                     : REPLTLS (track 0) (SSL)
      Start/Restart count   : 1
      Current state         : STATE_META_PEER_INFO

   RECEIVER thread(s) (RECEIVER:139870719887104):
    For                     : REPLTLS (track 0) (SSL)
      Start/Restart count   : 1
      Current state         : STATE_RCVR_READ_NETWORK_LOOP
   ...
   ```

You have successfully verified that TLS for replication is being used.

Use CA-Signed Certificates for Client/Server TLS Encryption

The TimesTen Operator can use certificates signed by a certificate authority (CA) for automatic configuration of client/server TLS encryption.

Topics:

- Import CA-Signed Certificates for Client/Server TLS Encryption
- Rotate the Server Certificate
- Rotate the Root Certificate

Import CA-Signed Certificates for Client/Server TLS Encryption

The TimesTen Operator can create Oracle Wallets, use CA-signed certificates, and automatically configure client/server encryption using Transport Layer Security (TLS).

The configuration process assumes that you have followed the steps to obtain CA-signed certificates. For example, if you have an intermediate CA, you need an intermediate certificate signed by a root CA, a server certificate signed by the intermediate CA, the root CA, and a server private key. Once you have the certificates and server private key, you need to concatenate them into a `pkcs12` file. Next, you perform steps necessary for the TimesTen Operator to import the certificates and configure client/server TLS encryption.

1. Concatenate the server certificate, the intermediate certificate, and the root CA, making a full certificate chain.

   ```
   cat server.pem intermediate.pem root.pem > completeServer.pem
   ```

2. Combine the certificates with the server's private key to create a `PKCS#12` file, protected with a password.

   ```
   openssl pkcs12 -export -in completeServer.pem -inkey privkey.pem -out
   server.p12 -passout pass:welcome1
   ```

3. Create a Kubernetes Secret.

   ```
   kubectl create secret generic tt-server-pfx-secret --from-
   file=server=server.p12 --from-literal=password=welcome1
   ```

4. Create a TimesTenClassic object using the `customClientTLS` section of the TimesTenClassic CRD.

   ```
   apiVersion: timesten.oracle.com/v5
   kind: TimesTenClassic
   metadata:
     name: sampletls
   spec:
     ttspec:
       storageClassName: local-storage
       storageSize: 50Gi
       image: container-registry.oracle.com/timesten/timesten:26.1.1.36.0
       imagePullSecret: sekret
       customClientTLS:
         encryption: required
         gracePeriod: 48
         ciphersuites: TLS_RSA_WITH_AES_128_GCM_SHA256
         serverCert: tt-server-pfx-secret
     dbConfigMap:
     - sampletls
   ```

5. Create the TimesTenClassic object.

   ```
   kubectl create -f sampletls
   ```

The TimesTen Operator performs the steps necessary to configure TLS for client/server encryption.

Rotate the Server Certificate

The TimesTen Operator can rotate the server certificate.

In this example, assume you want to create a new server certificate. The root certificate does not change.

1. Concatenate the new server certificate, the original intermediate certificate, and the original root CA, making a full certificate chain.

   ```
   cat new_server.pem intermediate.pem root.pem > completeServer.pem
   ```

2. Combine the certificates with the server's private key to create a `PKCS#12` file, protected with a password.

   ```
   openssl pkcs12 -export -in completeServer.pem -inkey privkey.pem -out
   server.p12 -passout pass:welcome1
   ```

3. Update the Kubernetes Secret. This Secret already exists in your namespace. See Import CA-Signed Certificates for Client/Server TLS Encryption.

   ```
   kubectl create secret generic tt-server-pfx-secret --from-file=server.p12
   --dry-run=client -o yaml | kubectl apply -f -
   ```

The TimesTen Operator recognizes the Kubernetes Secret has changed and takes appropriate action to rotate the server certificate.

Rotate the Root Certificate

The TimesTen Operator can rotate the root certificate.

In this example, assume you want to create a new root certificate, a new intermediate certificate, and a new root certificate.

1. Concatenate the new server certificate, the new intermediate certificate, and the new root CA, making a full certificate chain.

   ```
   cat new_server.pem new_intermediate.pem new_root.pem > completeServer.pem
   ```

2. Combine the certificates with the server's private key to create a `PKCS#12` file, protected with a password.

   ```
   openssl pkcs12 -export -in completeServer.pem -inkey privkey.pem -out
   server.p12 -passout pass:welcome1
   ```

3. Update the Kubernetes Secret. This Secret already exists in your namespace. See Import CA-Signed Certificates for Client/Server TLS Encryption.

   ```
   kubectl create secret generic tt-server-pfx-secret --from-file=server.p12
   --dry-run=client -o yaml | kubectl apply -f -
   ```

The TimesTen Operator recognizes the Kubernetes Secret has changed and takes appropriate action to rotate the server certificate.

Automatically Configure Client/Server TLS

The TimesTen Operator can automatically create self-signed certificates and configure TimesTen to use those certificates for client/server TLS encryption. This automation eliminates the requirement for you to manually run the TimesTen `ttCreateCerts` utility to create self-signed certificates as well to perform additional manual steps to make the resulting certificates available to TimesTen on TimesTen servers and TimesTen clients.

Topics in this section include the following:

- About Configuring a TimesTenClassic Object for Automatic Client/Server TLS Encryption
- About the Automation Process
- How-to Example

About Configuring a TimesTenClassic Object for Automatic Client/Server TLS Encryption

You can customize your TimesTenClassic object to enable automatic client/server TLS encryption by including a `.spec.ttspec.clientTLS` section in your TimesTenClassic object definition. When you include the `.spec.ttspec.clientTLS` section in your TimesTenClassic object definition and set `.spec.ttspec.clientTLS.auto` to `true`, the TimesTen Operator notices and takes action to create self-signed certificates and configure TimesTen to use those certificates for client/server encryption.

Here is a snippet of a TimesTenClassic object that uses `.spec.ttspec.clientTLS`.

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: sampletls
spec:
  ttspec:
    storageClassName: oci-bv
    clientTLS:
      auto: true
      ciphersuites: SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
      eccurve: p256
      encryption: required
      signAlg: ecdsasha384
      validity: 365
    storageSize: 10Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    dbConfigMap:
    - sampletls
```

Let's look at `.spec.ttspec.clientTLS` in more detail:

- `auto`: Determines if automatic client/server encryption is enabled. Set `auto` to `true` to enable automatic client/server encryption. The default is `false`. If set to false, there is no automatic client/server encryption for this TimesTenClassic object.
- `ciphersuites`: Defines the cipher suite(s) used for client/server communication. You can specify one or more cipher suites. If there is more than one cipher suite, use a comma-separated list, and list the cipher suites in order of preference. This example specifies `SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384`.

  The TimesTen Operator first checks to see if there is a `ciphersuites` entry in the `db.ini` file.

  - If there is an entry, the TimesTen Operator uses it.
  - If there is no entry, the TimesTen Operator uses the value specified in `.spec.ttspec.clientTLS.ciphersuites`.

  - If `.spec.ttspec.clientTLS.auto` is `true`, and there is no value specified in either the `db.ini` file or in `.spec.ttspec.clientTLS.ciphersuites`, the TimesTen Operator sets the value to `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256`.

  The TimesTen Operator adds the `ciphersuites` value to the TimesTen Server's `sys.odbc.ini` file.

- `eccurve`: Defines the elliptical curve signing algorithm. This example specifies `p256`.

  When the TimesTen Operator runs the TimesTen `ttCreateCerts` utility, it supplies the `.spec.ttspec.clientTLS.eccurve` value to the `-eccurve` option of the TimesTen `ttCreateCerts` utility. If you do not specify a value, the default is `p384`. For a list of supported values, see TimesTenClassicSpecSpecClientTLS.

- `encryption`: Defines the encryption setting for client/server access. This example specifies `required`.

  The TimesTen Operator first checks to see if there is an `encryption` entry in the `db.ini` file for the object.

  - If there is an entry, the TimesTen Operator uses it.
  - If there is no entry, the TimesTen Operator uses the value specified in `.spec.ttspec.clientTLS.encryption`.
  - If `.spec.ttspec.clientTLS.auto` is `true`, and there is no value specified in either the `db.ini` file or in `.spec.ttspec.clientTLS.encryption`, the default is `accepted`. For a list of supported values, see TimesTenClassicSpecSpecClientTLS.

  The TimesTen Operator adds the `encryption` value to the TimesTen Server's `sys.odbc.ini` file.

- `signAlg`: Defines the elliptical curve signing algorithm. This example specifies `ecdsasha384`.

  When the TimesTen Operator runs the TimesTen `ttCreateCerts` utility, it supplies the `.spec.ttspec.clientTLS.signAlg` value to the `-sign_alg` option of the TimesTen `ttCreateCerts` utility. If you do not specify a value, the default is `ecdsasha384`. For a list of supported values, see TimesTenClassicSpecSpecClientTLS.

- `validity`: Defines the number of days the created certificate is valid. This example specifies `365`.

  When the TimesTen Operator runs the TimesTen `ttCreateCerts` utility, it supplies the `.spec.ttspec.clientTLS.validity` value to the `-validity` option of the TimesTen `ttCreateCerts` utility. If you do not specify a value, the default is `3650`. For a list of supported values, see TimesTenClassicSpecSpecClientTLS.

For more information, see the following:

- TimesTenClassicSpecSpecClientTLS in this book.
- Configuration for TLS for Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.

About the Automation Process

Let's review the actions the TimesTen Operator takes when you specify `.spec.ttspec.clientTLS` and set `.spec.ttspec.clientTLS.auto: true` in a TimesTenClassic object definition:

- The TimesTen Operator runs the TimesTen `ttCreateCerts -dir <temporary_directory>` utility. The TimesTen Operator may supply additional options to the `ttCreateCerts` utility depending on the settings you provided in `.spec.ttspec.clientTLS`.

  For more information, see

  - About Configuring a TimesTenClassic Object for Automatic Client/Server TLS Encryption
  - ttCreateCerts utility in the *Oracle TimesTen In-Memory Database Reference*

- The TimesTen Operator creates two directories that contain Oracle wallets. These wallets contain the self-signed certificates that were created by the `ttCreateCerts` utility:

  - `/serverWallet/cwallet.sso`: Contains the self-signed certificate for TimesTen servers.
  - `/clientWallet/cwallet.sso`: Contains the self-signed certificate for TimesTen clients.

  As an example, let's look at a directory structure for the `tt` container in a Pod named `sampletls-0`:

```
[timesten@sampletls-0 /]$ pwd
/
[timesten@sampletls-0 /]$ ls -a serverWallet
.  ..  cwallet.sso
[timesten@sampletls-0 /]$ ls -a clientWallet
.  ..  cwallet.sso
```

  Note that the `/serverWallet/cwallet.sso` and the `/clientWallet/cwallet.sso` wallets exist. These wallets contain the self-signed certificates required for client/server TLS encryption.

- The TimesTen Operator creates two Kubernetes Secrets:

  - `<name_of_TimesTenClassic_object>-server` where `<name_of_TimesTenClassic_object>` is the name of the TimesTenClassic object: This is the Kubernetes Secret that contains the self-signed certificate that is stored in `/serverWallet/cwallet.sso` and used for TimesTen servers.

    The containers that run TimesTen are configured to mount this Secret. As a result, this file is available in the TimesTen containers.

  - `<name_of_TimesTenClassic_object>-client` where `<name_of_TimesTenClassic_object>` is the name of the TimesTenClassic object: This is the Kubernetes Secret that contains the self-signed certificate that is stored in `/clientWallet/cwallet.sso` and used for TimesTen clients.

  As an example, let's look at the Kubernetes Secrets created by the TimesTen Operator for a TimesTenClassic object named `sampletls`.

```
kubectl get secrets
NAME                                       TYPE
DATA   AGE
sampletls-client                           Opaque
1      21m
sampletls-server                           Opaque
1      21m
...
```

- The TimesTen Operator checks to see if the `/serverWallet` directory in the `tt` container exists. If it does, appropriate `Wallet`, `Ciphersuites`, and `Encryption` entries are added to the `sys.odbc.ini` file being generated. These entries could be located in the `db.ini` metadata file or in `.spec.ttspec.clientTLS` or both. See About Configuring a TimesTenClassic Object for Automatic Client/Server TLS Encryption.

After completing these steps, the TimesTen Operator has automatically configured TimesTen servers for client/server TLS encryption.

For client applications, when you define Pods that run your applications, you can cause the client Secret to be mounted in these Pods. You can also include a `wallet` entry in your `sys.odbc.ini` file that directly references the wallet from this Secret. There are steps in the Configure and Deploy the TimesTenClassic Object that show you how to do this.

How-to Example

Let's walk-through an example that illustrates how to configure your TimesTenClassic object for automatic client/server TLS encryption and let's observe how the TimesTen Operator automates the process.

- Before You Begin
- Configure and Deploy the TimesTenClassic Object

Before You Begin

This example assumes that the TimesTenClassic CRD is deployed in your Kubernetes cluster and the TimesTen Operator is running in your namespace at namespace-scope. The example also assumes you have created metadata files and created a Kubernetes Configmap for these metadata files.

Let's confirm the TimesTenClassic CRD is deployed and the TimesTen Operator is running. Next, let's create some metadata files and create a Configmap for these metadata files. These metadata files and their content are not required for automatically configuring client/server TLS. They are used for explanatory purposes.

1. Confirm the TimesTenClassic CRD exists in your Kubernetes cluster.

   ```
   kubectl get crds | grep timesten
   ```

   The output is similar to the following:

   ```
   timestenclassics.timesten.oracle.com              2025-03-28T16:34:33Z
   ```

2. Confirm the TimesTen Operator is running in your namespace at namespace-scope.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                READY   STATUS    RESTARTS   AGE
   timesten-operator-79bddcc446-nktcz  1/1     Running   0          3m54s
   ```

3. Create the metadata files.

a. From a directory of your choice, create an empty subdirectory for the metadata files. This example creates the `cm` subdirectory.

```
mkdir cm
```

b. Using an editor of your choice, create your desired metadata files. Exit from your editor after creating each file.

`db.ini`:

```
vi cm/db.ini

PermSize=200
DatabaseCharacterSet=AL32UTF8
```

`adminUser`:

```
vi cm/adminUser

adminuser/adminuserpwd
```

`schema.sql`

```
vi cm/schema.sql

create table adminuser.emp (id number not null primary key, name char
(32));
```

4. Create a Kubernetes Configmap for the metadata files.
   a. Create the configmap.

```
kubectl create configmap sampletls --from-file cm
```

   b. (Optional) Review the Configmap in your namespace.

```
kubectl describe configmap sampletls
```

The output is similar to the following:

```
Name:         sampletls
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>

Data
====
adminUser:
----
adminuser/adminuserpwd

db.ini:
----
PermSize=200
DatabaseCharacterSet=AL32UTF8
```

```
schema.sql:
----
create table adminuser.emp (id number not null primary key, name char
(32));


BinaryData
====

Events:  <none>
```

You are now ready to perform the steps to have the TimesTen Operator automatically configure client/server TLS encryption.

Configure and Deploy the TimesTenClassic Object

This example shows you how to configure and deploy a TimesTenClassic object for automatic client/server TLS encryption. This example uses a YAML manifest file.

1. From a directory of your choice, create the YAML manifest file.

   ```
   vi sampletls.yaml

   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   metadata:
     name: sampletls
   spec:
     ttspec:
       storageClassName: oci-bv
       clientTLS:
         auto: true
         ciphersuites: SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
         eccurve: p256
         encryption: required
         signAlg: ecdsasha384
         validity: 365
       storageSize: 10Gi
       image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
       imagePullSecret: sekret
       dbConfigMap:
       - sampletls
   ```

   Note the following:

   - `.spec.ttspec.clientTLS` is specified and `.spec.ttspec.clientTLS` is set to `true`. This directs the TimesTen Operator to automatically create self-signed certificates and configure TimesTen to use those certificates for client/server TLS encryption.
   - `.spec.ttspec.clientTLS.ciphersuites` is specified. The TimesTen Operator adds a `ciphersuites` entry with a value of `SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384` to the `sys.odbc.ini` file.
   - `.spec.ttspec.clientTLS.eccurve` is specified. The TimesTen Operator adds the -`eccurve` option to the `ttCreateCerts` utility and supplies of value of `p256` for this option.

- `.spec.ttspec.clientTLS.encryption` is specified. The TimesTen Operator adds an `encryption` entry with a value of `required` to the `sys.odbc.ini` file.
- `.spec.ttspec.clientTLS.signAlg` is specified. The TimesTen Operator adds the `-sign_alg` option to the `ttCreateCerts` utility and supplies of value of `ecdsasha384` for this option.
- `.spec.ttspec.clientTLS.validity` is specified. The TimesTen Operator adds the `-validity` option to the `ttCreateCerts` utility and supplies of value of `365` for this option.

2. Deploy the TimesTenClassic object.

   ```
   kubectl create -f sampletls.yaml
   ```

   The output is the following:

   ```
   timestenclassic.timesten.oracle.com/sampletls created
   ```

3. Monitor deployment.
   a. Check status.

      ```
      kubectl get ttc sampletls
      ```

      The output is similar to the following:

      ```
      NAME        STATE          ACTIVE   AGE
      sampletls   Initializing   None     2m33s
      ```

      The provisioning starts, but is not yet completed.
   b. Wait a few minutes, then check status again.

      ```
      kubectl get ttc sampletls
      ```

      The output is similar to the following:

      ```
      NAME        STATE    ACTIVE        AGE
      sampletls   Normal   sampletls-0   4m37s
      ```

      The provisioning process completes. The databases are up and running and operational, as indicated by the `Normal` state.
4. Verify the TimesTen Operator created the Kubernetes Secrets that contain the certificates for TimesTen servers and TimesTen clients.
   a. Review the Secrets.

      ```
      kubectl get secrets
      ```

      The output is similar to the following:

      ```
      NAME
      TYPE                                DATA   AGE
      ```

```
sampletls-client
Opaque                           1      21m
sampletls-server
Opaque                           1      21m
...
```

b. Confirm the contents of the `sampletls-server` Secret.

```
kubectl describe secret sampletls-server
```

The output is similar to the following:

```
Name:         sampletls-server
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>

Type:  Opaque

Data
====
cwallet.sso:  1525 bytes
```

The Secret contains the `cwallet.sso` wallet. This wallet contains the self-signed certificate for TimesTen servers.

c. Confirm the contents of the `sampletls-client` Secret.

```
kubectl describe secret sampletls-client
```

The output is similar to the following:

```
Name:         sampletls-client
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>

Type:  Opaque

Data
====
cwallet.sso:  1525 bytes
```

The Secret contains the `cwallet.sso` wallet. This wallet contains the self-signed certificate for TimesTen clients.

The TimesTen Operator ran the TimesTen `ttCreateCerts` utility to create self-signed certificates for client/server TLS encryption. The TimesTen Operator stored these certificates in Kubernetes Secrets.

5. Verify the TimesTen Operator automaticlly configured TimesTen to use the certificates for client/server TLS encryption.

a. Establish a shell in the `tt` container of the `sampletls-0` Pod.

```
kubectl exec -it sampletls-0 -c tt -- /bin/bash
```

b. Confirm the existence of the server and client wallets.

```
[timesten@sampletls-0 /]$ pwd
/


[timesten@sampletls-0 /]$ ls -a serverWallet
.  ..  cwallet.sso



[timesten@sampletls-0 /]$ ls -a clientWallet
.  ..  cwallet.sso
```

The `/serverWallet/cwallet.sso` wallet contains the self-signed certificate for TimesTen Servers. The `/clientWallet/cwallet.sso` wallet contains the self-signed certificate for TimesTen clients.

c. (Optional) Confirm the contents of `sys.odbc.ini` file.

```
[timesten@sampletls-0 ~]$ cat /tt/home/timesten/instances/instance1/
conf/sys.odbc.ini
```

The output is similar to the following:

```
[ODBC Data Sources]
sampletls=TimesTen 22.1 Driver
tt=TimesTen 22.1 Driver

[sampletls]
Datastore=/tt/home/timesten/datastore/sampletls
PermSize=200
DatabaseCharacterSet=AL32UTF8
DDLReplicationLevel=3
AutoCreate=0
ForceDisconnectEnabled=1
Wallet=/serverWallet
Ciphersuites=SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
Encryption=required

[tt]
Datastore=/tt/home/timesten/datastore/sampletls
PermSize=200
DatabaseCharacterSet=AL32UTF8
DDLReplicationLevel=3
AutoCreate=0
ForceDisconnectEnabled=1
WaitForConnect=0
Wallet=/serverWallet
```

```
Ciphersuites=SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
Encryption=required
```

The TimesTen Operator correctly added appropriate `Wallet`, `Ciphersuites`, and `Encryption` entries to the `sys.odbc.ini` file. The values for these entries were supplied in `.spec.ttspec.clientTLS` and are correct.

   d. Exit from the shell.

6. Verify TLS is being used.

   The following steps assume you have successfully copied the client wallet to the application container that is running your TimesTen client instance and that you have configured the appropriate client-side attributes. For more information about TimesTen client-side attributes, see Task 4: Configure the Client for TLS in the *Oracle TimesTen In-Memory Database Security Guide*.

   a. Establish a shell in the application container that contains your TimesTen client instance.

```
kubectl exec -it client-0 -c tt -- /bin/bash
```

   b. Use `ttIsqlCS` to connect to the `sampletls` database.

```
[timesten@sampletls-0]$ ttisqlcs -connstr
"TTC_SERVER1=sampletls-0.sampletls.mynamespace.svc.cluster.local;TTC_SER
VER2=sampletls-1.sampletls.mynamespace.svc.cluster.local;TTC_SERVER_DSN=
sampletls;UID=adminuser;PWD=adminuserpwd;wallet=/
clientWallet;ciphersuites=SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384;encryp
tion=required";
```

   The output is similar to the following:

```
Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights
reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect
"TTC_SERVER1=sampletls-0.sampletls.mynamespace.svc.cluster.local;TTC_SER
VER2=sampletls-1.sampletls.mynamespace.svc.cluster.local;TTC_SERVER_DSN=
sampletls;UID=adminuser;PWD=********;wallet=/
clientWallet;ciphersuites=SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384;encryp
tion=required";
Connection successful:
DSN=;TTC_SERVER=sampletls-0.sampletls.mynamespace.svc.cluster.local;TTC_
SERVER_DSN=sampletls;UID=adminuser;DATASTORE=/tt/home/timesten/
datastore/
sampletls;DATABASECHARACTERSET=AL32UTF8;CONNECTIONCHARACTERSET=US7ASCII;
AUTOCREATE=0;PERMSIZE=200;DDLREPLICATIONLEVEL=3;FORCEDISCONNECTENABLED=1
;Encryption=Required;Wallet=/
clientWallet;CipherSuites=SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384;
(Default setting AutoCommit=1)
```

c. Use the TimesTen `sqlgetconnectattr` command in `ttIsqlCS` to verify TLS is being used. A return value of `1` indicates TLS is being used.

```
Command> sqlgetconnectattr tt_tls_session;
```

The output is the following:

```
TT_TLS_SESSION = 1 (SQL_TRUE)
```

Congratulations! You successfully configured a TimesTenClassic object for automatic client/server TLS encryption. After you deployed the TimesTenClassic object in your namespace, the TimesTen Operator automatically created self-signed certificates and configured TimesTen to use those certificates for client/server TLS encryption.

Configure TLS for Client/Server

You can configure TLS for Client/Server to ensure secure network communication between TimesTen clients and servers. See Transport Layer Security for TimesTen Client/Server in the Oracle TimesTen In-Memory Database Security Guide for detailed information.

There are both server-side and client-side configuration requirements for using TLS for Client/Server. These requirements are detailed in these sections:

- Configuration Requirements for the Server
- Configuration Requirements for the Client

Configuration Requirements for the Server

These sections discuss the configuration requirements for the server. The sections also include an example of how to configure TLS for the server in your Kubernetes cluster.

- Overview of Metadata Files and Kubernetes Facilities
- Create a Kubernetes Secret for the csWallet Metadata File
- Create a ConfigMap for the Server-Side Attributes
- Create a TimesTenClassic Object
- Monitor Deployment of the TimesTenClassic Object

Overview of Metadata Files and Kubernetes Facilities

The `/ttconfig/csWallet` metadata file is required for TLS support for Client/Server. (The `/ttconfig` directory is located in the containers of your TimesTen databases.) This file must contain the `cwallet.sso` file (the Oracle wallet) that was generated when you created the TLS certificates. This file is the Oracle wallet required for the server. Recall that this file was located in the `/scratch/ttuser/instance_dir/instance1/conf/serverWallet` directory. See Create TLS Certificates for Replication and Client/Server for information on creating these certificates. This wallet contains the credentials that are used for configuring TLS encryption between your TimesTen database and your Client/Server applications.

There are also server-side connection attributes that must be set. You can define these attributes in the `db.ini` metadata file. After the `db.ini` file is placed in the `/ttconfig` directory of the TimesTen containers, the Operator copies the contents of the `db.ini` file to the *timesten_home*/conf/sys.odbc.ini file located in the TimesTen containers. (Note that *timesten_home* is the TimesTen instance directory. This instance directory is /tt/home/timesten/instances/instance1 in your TimesTen containers.)

These required server-side attributes are: Wallet, CipherSuites, and Encryption. See Create a ConfigMap for the Server-Side Attributes for information on these attributes. Also see Server Attributes for TLS in the *Oracle TimesTen In-Memory Database Security Guide*.

In addition to the csWallet and the db.ini metadata files, you may use other supported metadata files. See About Configuration Metadata Details for information on these supported metadata files.

You can include these metadata files in one or more Kubernetes facilities (for example, in a Kubernetes Secret, in a ConfigMap, or in an init container). This ensures the metadata files are populated in the /ttconfig directory of the TimesTen containers. Note that there is no requirement as to how to get the metadata files into this /ttconfig directory. See Populate the /ttconfig Directory.

The following example includes the csWallet metadata file in a Kubernetes Secret. It also creates the db.ini, the adminUser, and the schema.sql metadata files and includes these metadata files in a ConfigMap.

Create a Kubernetes Secret for the csWallet Metadata File

This section creates the cs-tls Kubernetes Secret. The cs-tls Secret will contain the csWallet metadata file.

On your Linux development host:

1. From the directory of your choice, create an empty subdirectory. This example creates the serverWallet subdirectory. (The serverWallet directory is used in the remainder of this example to denote this directory.)

   ```
   % mkdir -p serverWallet
   ```

2. Copy the cwallet.sso file into the serverWallet directory that you just created. Recall that the cwallet.sso file was generated when you used the ttCreateCerts utility to create the TLS certificates. Also recall that this file was located in the /scratch/ttuser/instance_dir/instance1/conf/serverWallet directory. See "Create TLS Certificates for Replication and Client/Server" for information.

   ```
   % cp /scratch/ttuser/instance_dir/instance1/conf/serverWallet/cwallet.sso
   serverWallet/cwallet.sso
   ```

3. Create the Kubernetes Secret.

   In this example:

   - The name of the Secret is cs-tls. Replace cs-tls with a name of your choosing. (cs-tls is represented in **bold**.)
   - The name of the metadata file required for TLS for Client/Server is csWallet (represented in **bold**).
   - The location of the wallet directory is serverWallet (in this example, represented in **bold**). If you use a different directory, replace serverWallet with the name of your directory.
   - The name of the Oracle wallet: cwallet.sso (represented in **bold**).

   Use the kubectl create command to create the Secret:

```
% kubectl create secret generic cs-tls
--from-file=csWallet=serverWallet/cwallet.sso
secret/cs-tls created
```

You have successfully created and deployed the `cs-tls` Kubernetes Secret. The `csWallet/cwallet.sso` file will later be available in the `/ttconfig` directory of the TimesTen containers. In addition, the file will be available in the `/tt/home/timesten/csWallet` directory of the TimesTen containers.

Create a ConfigMap for the Server-Side Attributes

This section creates the `cs-tls` ConfigMap. This ConfigMap contains the `db.ini`, the `adminUser`, and the `schema.sql` metadata files.

On your Linux development host:

1. From the directory of your choice, create an empty subdirectory for the metadata files. This example creates the `cm_csTLS` subdirectory. (The `cm_csTLS` directory is used in the remainder of this example to denote this directory.)

   ```
   % mkdir -p cm_csTLS
   ```

2. Navigate to the ConfigMap directory.

   ```
   % cd cm_csTLS
   ```

3. Create the `db.ini` file in this ConfigMap directory (`cm_csTLS`, in this example). In this `db.ini` file, define the server-side attributes for TLS for Client/Server. These server-side attributes will later be included in the `sys.odbc.ini file` located in the *`timesten_home`*`/conf` directory in your TimesTen containers. (Note that *`timesten_home`* is the TimesTen instance directory. This instance directory is `tt/home/timesten/instances/instance1` in your TimesTen containers.)

   These are the required server-side attributes for TLS for Client/Server:

   - `wallet`: This is the directory in your TimesTen containers that contains the server wallet. Specify `/tt/home/timesten/csWallet`.
   - `ciphersuites`: This is the cipher suite setting. You can specify more than one value. If you specify more than one value, separate each value by a comma. List the values in order of preference. There is no default value. Values are the following:
     – `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_256`
     – `SSL_ECDHE_ECDSA_WITH_AES_256_GCM_384`
     – `SSL_RSA_WITH_AES_128_CBC_SHA256`

     For TLS to be used, the server and the client settings must include at least one common suite. This example specifies `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_256`. See Server Attributes for TLS in the *Oracle TimesTen In-Memory Database Security Guide*.
   - `encryption`: This is the encryption setting for the server. This example specifies the `required` setting. See Server Attributes for TLS in the *Oracle TimesTen In-Memory Database Security Guide* for information on the valid encryption settings.

   This example also specifies the `PermSize` and the `DatabaseCharacterSet` connection attributes.

   ```
   vi db.ini

   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ```

```
wallet=/tt/home/timesten/csWallet
ciphersuites=SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
encryption=required
```

4. Create the `adminUser` file in this ConfigMap directory (`cm_csTLS`, in this example). In this `adminUser` file, create the `sampleuser` user with the `samplepw` password.

   ```
   vi adminUser

   sampleuser/samplepw
   ```

5. Create the `schema.sql` file in this ConfigMap directory (`cm_csTLS`, in this example). In this `schema.sql` file, define the `s` sequence and the `emp` table for the `sampleuser` user. The Operator will automatically initialize your database with these object definitions.

   ```
   vi schema.sql

   create sequence sampleuser.s;
   create table sampleuser.emp (
     id number not null primary key,
     name char(32)
   );
   ```

6. Create the ConfigMap. The files in the `cm_csTLS` directory are included in the ConfigMap and, later, will be available in the TimesTen containers.

   In this example:

   - The name of the ConfigMap is `cs-tls`. Replace `cs-tls` with a name of your choosing. (`cs-tls` is represented in **bold** in this example.)
   - This example uses `cm_csTLS` as the directory where the files that will be copied into the ConfigMap reside. If you use a different directory, replace `cm_csTLS` with the name of your directory. (`cm_csTLS` is represented in **bold** in this example.)

   Use the `kubectl create` command to create the ConfigMap:

   ```
   % kubectl create configmap cs-tls --from-file=cm_csTLS
   configmap/cs-tls created
   ```

7. Use the `kubectl describe` command to verify the contents of the ConfigMap. (`cs-tls`, in this example.)

   ```
   % kubectl describe configmap cs-tls
   Name:         cs-tls
   Namespace:    mynamespace
   Labels:       <none>
   Annotations:  <none>

   Data
   ====
   db.ini:
   ----
   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   wallet=/tt/home/timesten/csWallet
   ciphersuites=SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
   encryption=required


   schema.sql:
   ----
   create sequence sampleuser.s;
   create table sampleuser.emp (id number not null primary key, name char (32));
   ```

```
adminUser:
----
sampleuser/samplepw

Events:  <none>
```

You have successfully created and deployed the `cs-tls` ConfigMap.

Create a TimesTenClassic Object

This section creates the TimesTenClassic object. For detailed information about the TimesTenClassic object type, see Syntax for the TimesTenClassic Object Type.

Perform these steps:

1. Create an empty YAML file. You can choose any name, but you may want to use the same name you used for the name of the TimesTenClassic object. (In this example, `cstls`.) The YAML file contains the definitions for the TimesTenClassic object. See TimesTenClassicSpecSpec for information on the fields that you must specify in this YAML file as well as the fields that are optional.

   In this example, the fields of particular interest for TLS Client/Server are:

   - `dbSecret`: This example uses one Kubernetes Secret (called `cs-tls`) for the `csWallet` metadata file.
   - `dbConfigMap`: This example uses one ConfigMap (called `cs-tls`). The `db.ini` file is contained in the `cs-tls` ConfigMap. Recall that the `db.ini` file contains the server-side attributes for TLS for Client/Server.

   In addition, this example includes:

   - `name`: Replace `cstls` with the name of your TimesTenClassic object.
   - `storageClassName`: Replace `oci-bv` with the name of the storage class used to allocate PersistentVolumes to hold TimesTen.
   - `storageSize`: Replace `250Gi` with the amount of storage that should be requested for each Pod to hold TimesTen. Note: This example assumes a production environment and uses a value of `250Gi` for `storageSize`. For demonstration purposes, a value of `50Gi` is adequate. See the `storageSize` and the `logStorageSize` entries in "Table 18-3" for information.
   - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` with the location and name of your image.
   - `imagePullSecret`: Replace `sekret` with the image pull secret that Kubernetes should use to fetch the TimesTen image.

   ```
   % vi cstls.yaml

   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   metadata:
     name: cstls
   spec:
     ttspec:
       storageClassName: oci-bv
       storageSize: 250Gi
       image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
       imagePullSecret: sekret
       dbConfigMap:
   ```

```
    - **cs-tls**
    **dbSecret**:
    - **cs-tls**
```

2. Use the `kubectl create` command to create the TimesTenClassic object from the contents of the YAML file (in this example, `cstls.yaml`). Doing so begins the process of deploying your active standby pair of TimesTen databases in the Kubernetes cluster.

   ```
   % kubectl create -f cstls.yaml
   timestenclassic.timesten.oracle.com/cstls created
   ```

You have successfully created the TimesTenClassic object in the Kubernetes cluster. The process of deploying your TimesTen databases begins, but is not yet complete.

Monitor Deployment of the TimesTenClassic Object

Use the `kubectl get` and the `kubectl describe` commands to monitor the progress of the active standby pair as it is provisioned.

1. Use the `kubectl get` command and review the `STATE` field. Observe the value is `Initializing`. The active standby pair provisioning has begun, but is not yet complete.

   ```
   % kubectl get ttc cstls
   NAME    STATE          ACTIVE   AGE
   cstls   Initializing   None     15s
   ```

2. Use the `kubectl get` command again to see if value of the `STATE` field has changed. In this example, the value is `Normal`, indicating the active standby pair of databases are now provisioned and the process is complete.

   ```
   % kubectl get ttc cstls
   NAME    STATE    ACTIVE    AGE
   cstls   Normal   cstls-0   3m30s
   ```

3. Use the `kubectl describe` command to view the active standby pair provisioning in detail.

   Note the following have been correctly set in the `cstls` TimesTenClassic object definition:

   - The `cs-tls` Secret has been correctly referenced in the `dbSecret` field (represented in **bold**).
   - The `cs-tls` Configmap has been correctly referenced in the `dbConfigMap` field (represented in **bold**).

   Note: Note all of the output is shown in this example.

   ```
   % kubectl describe ttc cstls
   Name:         cstls
   Namespace:    mynamespace
   Labels:       <none>
   Annotations:  <none>
   API Version:  timesten.oracle.com/v4
   Kind:         TimesTenClassic
   Metadata:
     Creation Timestamp:  2025-01-16T19:08:03Z
     Generation:          1
     Resource Version:    75491472
     Self Link:
   /apis/timesten.oracle.com/v4/namespaces/mynamespace/timestenclassics/cstls
     UID:                 150128b3-10ac-11eb-b019-d681454a288b
   Spec:
     Ttspec:
       Db Config Map:
         **cs-tls**
   ```

```
        Db Secret:
          cs-tls
        Image:              container-registry.oracle.com/timesten/timesten:26.1.1.1.0
        Image Pull Policy:   Always
        Image Pull Secret:   sekret
        Storage Class Name:  oci
        Storage Size:        250Gi
...
Events:
  Type  Reason       Age    From       Message
  ----  ------       ----   ----       -------
  -     Create       4m21s  ttclassic  Service cstls created
  -     Create       4m21s  ttclassic  StatefulSet cstls created
  -     Create       4m21s  ttclassic  Secret tt150128b3-10ac-11eb-b019-d681454a288b
created
  -     StateChange  3m5s   ttclassic  Pod cstls-1 Daemon Up
  -     StateChange  3m5s   ttclassic  Pod cstls-0 Agent Up
  -     StateChange  3m5s   ttclassic  Pod cstls-0 Release 26.1.1.1.0
  -     StateChange  3m5s   ttclassic  Pod cstls-1 Agent Up
  -     StateChange  3m5s   ttclassic  Pod cstls-1 Release 26.1.1.1.0
  -     StateChange  3m5s   ttclassic  Pod cstls-0 Daemon Up
  -     StateChange  116s   ttclassic  Pod cstls-0 Database Loaded
  -     StateChange  116s   ttclassic  Pod cstls-0 Database Updatable
  -     StateChange  116s   ttclassic  Pod cstls-0 CacheAgent Not Running
  -     StateChange  116s   ttclassic  Pod cstls-0 RepAgent Not Running
  -     StateChange  116s   ttclassic  Pod cstls-0 RepState IDLE
  -     StateChange  116s   ttclassic  Pod cstls-0 RepScheme None
  -     StateChange  115s   ttclassic  Pod cstls-0 RepAgent Running
  -     StateChange  115s   ttclassic  Pod cstls-0 RepScheme Exists
  -     StateChange  115s   ttclassic  Pod cstls-0 RepState ACTIVE
  -     StateChange  96s    ttclassic  Pod cstls-1 Database Loaded
  -     StateChange  96s    ttclassic  Pod cstls-1 Database Not Updatable
  -     StateChange  96s    ttclassic  Pod cstls-1 CacheAgent Not Running
  -     StateChange  96s    ttclassic  Pod cstls-1 RepAgent Not Running
  -     StateChange  96s    ttclassic  Pod cstls-1 RepScheme Exists
  -     StateChange  96s    ttclassic  Pod cstls-1 RepState IDLE
  -     StateChange  90s    ttclassic  Pod cstls-1 RepAgent Running
  -     StateChange  84s    ttclassic  Pod cstls-1 RepState STANDBY
  -     StateChange  84s    ttclassic  TimesTenClassic was Initializing, now Normal
```

Your active standby pair of TimesTen databases are successfully deployed (as indicated by `Normal`.)

Configuration Requirements for the Client

These sections cover the client requirements for TLS.

- Copy a Client Wallet
- Configure Client-Side Attributes

Copy a Client Wallet

When you used the `ttCreateCerts` utility to create TLS certificates, the `cwallet.sso` wallet file located in the `/scratch/ttuser/instance_dir/instance1/conf/ clientWallet` directory was generated. This file must be copied to the application container that is running your TimesTen client instance. See "Create TLS Certificates for Replication and Client/Server" for information on creating the TLS certificates.

This example uses the `kubectl cp` command to copy the `/scratch/ttuser/instance_dir/instance1/conf/clientWallet/cwallet.sso` file from your Linux development host to the application container running your TimesTen client instance.

1. Use the `kubectl exec -it` command to invoke the shell in the application container that contains your TimesTen client instance. (`cstls-0`, in this example).

   ```
   % kubectl exec -it cstls-0 -c tt -- /bin/bash
   ```

2. From the shell just invoked, and from the directory of your choice, create an empty subdirectory. This example creates the `clientWallet` subdirectory.

   ```
   % mkdir -p clientWallet
   ```

3. From your Linux development host, use the `kubectl cp` command to copy the `cwallet.sso` file from the `/scratch/ttuser/instance_dir/instance1/conf/clientWallet` directory on your Linux development host to the `clientWallet` directory that you just created. (This directory is located in the application container that is running your TimesTen client instance.) Recall that the `cwallet.sso` file was generated when you used the `ttCreateCerts` utility to create the TLS certificates. See Create TLS Certificates for Replication and Client/Server for information.

   ```
   % kubectl cp /scratch/ttuser/instance_dir/instance1/conf/clientWallet/
   cwallet.sso cstls-0:clientWallet/cwallet.sso -c tt
   ```

4. From your shell, verify the `cwallet.sso` file is located in the `clientWallet` directory.

   ```
   % ls clientWallet
   cwallet.sso
   ```

You have successfully copied the `cwallet.sso` client wallet file to the application container that is running your TimesTen client instance.

Configure Client-Side Attributes

You must set client-side attributes for TLS for Client/Server. The attributes can be set in the client DSN definition in *`timesten_home`*`/conf/sys.odbc.ini` or in an appropriate Client/Server connection string. See About Using Client/Server Drivers for additional information.

These are the required client-side attributes for TLS for Client/Server:

- `wallet`: This is the directory that contains the `cwallet.sso` client wallet file. This directory is located in your application container that is running the TimesTen client instance. There is no default directory. In this example, recall that the `clientWallet` directory was created to denote this directory. (See Copy a Client Wallet for information.) For purposes of this example, the full path to the `clientWallet` directory is `/tt/home/timesten/clientWallet`. Therefore, in this example, `/tt/home/timesten/clientWallet` is used to denote this directory.
- `ciphersuites`: This is the cipher suite setting. You can specify more than one value. If you specify more than one value, separate each value by a comma. List the values in order of preference. There is no default value. Values are the following:
  - `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_256`
  - `SSL_ECDHE_ECDSA_WITH_AES_256_GCM_384`
  - `SSL_RSA_WITH_AES_128_CBC_SHA256`

  For TLS to be used, the server and the client settings must include at least one common suite. This example specifies `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_256`. See Configuration for TLS for Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.

- `encryption`: This is the encryption setting for the client. This example specifies the `required` setting. See Configuration for TLS for Client/Server in the *Oracle TimesTen In-Memory Database Security Guide* for information on the valid encryption settings.

This example uses a connection string to connect to the `cstsl` database as the `sampleuser` user. The `sampleuser` user was created by the Operator and already exists in the `cstsl` database. The example then uses the `sqlgetconnectattr` command from `ttIsqlCS` on the client to verify TLS is configured correctly on the Server and on the Client and TLS is being used.

1. Connect to the database.

```
% ttIsqlcs -connstr "TTC_SERVER1=cstls-0.cstls.mynamespace.svc.cluster.local;
TTC_SERVER2=cstls-1.cstls.mynamespace.svc.cluster.local;
TTC_SERVER_DSN=cstls;UID=sampleuser;PWD=samplepw;
WALLET=tt/home/timesten/clientWallet;
CIPHERSUITES=SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256;
ENCRYPTION=required";

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Type ? or "help" for help, type "exit" to quit ttIsql.



connect "TTC_SERVER1=cstls-0.cstls.mynamespace.svc.cluster.local;
TTC_SERVER2=cstls-1.cstls.mynamespace.svc.cluster.local;
TTC_SERVER_DSN=cstls;UID=sampleuser;PWD=********;
WALLET=tt/home/timesten/clientWallet;
CipherSuites=SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256;
ENCRYPTION=REQUIRED;";
Connection successful:
DSN=;TTC_SERVER=cstls-0.cstls.mynamespace.svc.cluster.local;
TTC_SERVER_DSN=cstls;UID=sampleuser;
DATASTORE=/tt/home/timesten/datastore/cstls;DATABASECHARACTERSET=AL32UTF8;
CONNECTIONCHARACTERSET=AL32UTF8;AUTOCREATE=0;PERMSIZE=200;
DDLREPLICATIONLEVEL=3;FORCEDISCONNECTENABLED=1;(SERVER)ENCRYPTION=Required;
(SERVER)WALLET=file:/tt/home/timesten/csWallet;(client)Encryption=Required;
(client)Wallet=/tt/home/timesten/clientWallet;
(client)CipherSuites=SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256;
(Default setting AutoCommit=1)
```

2. Use the `sqlgetconnectattr` command in `ttIsqlCS` to verify TLS is being used. A return value of `1` indicates TLS is being used.

```
Command> sqlgetconnectattr tt_tls_session;
TT_TLS_SESSION = 1 (SQL_TRUE)
```

You have successfully connected to the database and verified that TLS for Client/Server is being used.

16

Handle Failover and Recovery in TimesTen Classic

Learn about how the TimesTen Operator handles failover and recovery.

About Node Failure in Kubernetes

Learn about node failure in Kubernetes and how the TimesTen Operator detects it and takes appropriate action.

Topics:

How Kubernetes Reports Node Status

The status of a Node in Kubernetes is critical in managing a Kubernetes cluster. Kubernetes provides details about the status of a Node. In particular, the `conditions` field of a Node's status provides information about the status of running Nodes. For example, the `Ready` condition provides information about the readiness and health of a Node.

The values for the `Ready` condition are as follows:

- `True`: The Node is healthy and is ready to accept Pods.
- `False`: The Node is not healthy and is not accepting Pods.
- `Unknown`: The Node controller has not recently heard from the Node.

You can get the status of a Node by using the `kubectl get nodes` and `kubectl describe node` commands. For example:

```
kubectl get nodes
NAME      STATUS   ROLES                         AGE    VERSION
NodeA     Ready    control-plane,etcd,master     233d   v1.25.16+rke2r2
```

Kubernetes reports that `NodeA` is `Ready`.

```
kubectl describe node nodea
...
Conditions:
  Type                 Status  LastHeartbeatTime
LastTransitionTime                Reason                      Message
  ----                 ------  -----------------
------------------                ------                      -------
  ...
  Ready                True    Thu, 16 Jan 2025 14:04:26 +0000   Thu, 09 Jan
2025 05:01:08 +0000   KubeletReady                 kubelet is posting ready
status
```

Kubernetes reports that the `Ready` condition for `NodeA` is `True` and `NodeA` is accepting Pods.

For more information, see https://kubernetes.io/docs/reference/node/node-status/ in the Kubernetes documentation.

How the TimesTen Kubernetes Operator Handles Node Failure

Kubernetes does a good job of detecting and resolving Node and Pod failure. However, there could be cases where Kubernetes cannot resolve failure. Let's look at an example that could affect TimesTen databases that reside in containers in Pods on one or more Nodes in a Kubernetes cluster. Let's then examine what you can do to have the TimesTen Operator detect this situation and take appropriate action.

In a Kubernetes cluster, assume you use the local volume provisioner to make storage on each Kubernetes Node available as persistent storage for Pods running on the Node. A drawback of this approach is that the storage on one Node is not available to other Nodes. Consider the following scenario:

- There are three nodes in the cluster (Node A, Node B, and Node C).
- TimesTen is running on Node A and Node B.
- Node A goes down and is unavailable.

Kubernetes detects the failure of Node A, but cannot automatically create a new Pod on Node C to run TimesTen. This is because the persistent volumes used by TimesTen are local to Node A and therefore Node C cannot access these persistent volumes. As a result, if Node A is down and unavailable, Kubernetes cannot create a new Pod on Node C. The TimesTen Operator can correctly fail over the database to Node B, but cannot bring up a replacement for Node A. Therefore, there is no redundancy in the cluster until Node A comes back up.

You can configure the TimesTen Operator to detect such a situation and take appropriate action to reconfigure and automatically start TimesTen on Node C.

Here's how:

The `.spec.ttspec.deleteDbOnNotReadyNode` datum of a TimesTenClassic object allows you to direct the TimesTen Operator to detect situations where a Node is not ready (or unknown) for a specific period of time. In such cases, if the `.spec.ttspec.deleteDbOnNotReadyNode` is specified, the TimesTen Operator takes appropriate action to remedy the situation. For more information about the `.spec.ttspec.deleteDbOnNotReadyNode` datum, see the `deleteDbOnNotReadyNode` entry in Table 18-3.

Let's look at this in further detail.

Approximately every `.spec.ttspec.pollingInterval` seconds, the TimesTen Operator reconciles each TimesTenClassic object. During this reconciliation, the TimesTen Operator examines the state of each Pod associated with a TimesTenClassic object. In addition, the TimesTen Operator also retrieves the state of the Node on which the Pod is running. If a Pod is scheduled on a Node that is not ready (or unknown), the TimesTen Operator records the time in the TimesTenClassic object's status.

During the next reconciliation (`.spec.ttspec.pollingInterval` later), if the Pod is assigned to the same Node and the Node is still not ready (or unknown), then the TimesTen Operator checks to see if the `.spec.ttspec.deleteDbOnNotReadyNode` is specified. If it is specified, the TimesTen Operator checks to see if the Node's `not ready` condition has existed for more than `.spec.ttspec.deleteDbOnNotReadyNode` seconds. If so, the TimesTen Operator deletes the Pod and the PVCs associated with the Pod. This causes Kubernetes to create a new Pod and new PVCs on a surviving Node. Once the Pod is scheduled and started by Kubernetes, the TimesTen Operator configures it as usual.

About Specifying the .spec.ttspec.deleteDbOnNotReadyNode Datum

You can specify the `.spec.ttspec.deleteDbOnNotReadyNode` datum for both replicated and non-replicated configurations.

Note

Specifying the `.spec.ttspec.deleteDbOnNotReadyNode` datum could result in the TimesTen Operator deleting PVCs. Deleting PVCs discards the on-disk copy of TimesTen databases. Use caution when specifying the `.spec.ttspec.deleteDbOnNotReadyNode` datum.

In a replicated environment, depending on your replication setting, deleting PVCs may not cause data loss. For example, assume the following:

- The `sample-0` database is active and the `sample-1` database is standby.
- The Node on which the `sample-0` database is running fails.
- The TimesTen Operator performs the steps to fail over to `sample-1`, making it the new active.
- Even if the Node on which `sample-0` was running comes back up, the TimesTen Operator duplicates the database on `sample-1` back to `sample-0`. In this case, the contents of the PVCs for `sample-0` are not relevant.

Similarly, if `sample-0` is the standby, when `sample-0` comes back up, the TimesTen Operator duplicates the database from `sample-1`. In this case, the database in the PVC on the failed node is not relevant.

In a non-replicated environment, there may be data loss. For example, there may be data in a database that is not in any other replica database. In this case, if the TimesTen Operator deletes PVCs associated with the database, there could be data loss.

In non-replicated environments where TimesTen is used as a read-only cache, specifying the `.spec.ttspec.deleteDbOnNotReadyNode` datum may be beneficial. If specified, the TimesTen Operator can re-provision the number of replicas, even if one Node fails.

About Kubernetes Events and TimesTen Operator Metrics

In these situations, the TimesTen Operator generates Kubernetes Events and TimesTen Operator metrics.

The Kubernetes Events are as follows:

- If the TimesTen Operator cannot retrieve one or more Nodes, it generates an appropriate Event, and continues as though `.spec.ttspec.deleteDbOnNotReadyNode` was not specified.
- If the TimesTen Operator cannot delete Pods or PVCs, it generates an appropriate Event.

The TimesTen Operator metrics are as follows:

- `timesten_pods_deleted_unschedulable`
- `timesten_pods_unschedulable`
- `timesten_pvcs_deleted_unschedulable`

For more information about these metrics, see TimesTen Kubernetes Operator Metrics.

About Handling Failover and Recovery

The Operator automatically detects failures of the active TimesTen database and the standby TimesTen database and works to fix any failures. When the Operator detects a failure of the active database, it promotes the standby TimesTen database to be the active. Client/server applications that are using the database are automatically reconnected to the new active database. Transactions in flight are rolled back. Prepared statements need to be re-prepared by the applications. The Operator will configure a new standby database.

Illustrate the Failover and Recovery Process

This example simulates a failure of the active TimesTen database. This is for demonstration purposes only. Do not do this in a production environment.

1. Use the `kubectl delete pod` command to delete the active database (`sample-0` in this case)

   ```
   % kubectl delete pod sample-0
   ```

2. Use the `kubectl describe` command to observe how the Operator recovers from the failure. The Operator promotes the standby database (`sample-1`) to be active. Any applications that were connected to the `sample-0` database are automatically reconnected to the `sample-1` database by TimesTen. After a brief outage, the applications can continue to use the database. See "About the High Level State of TimesTenClassic Objects" for information on the health and states of the active standby pair.

   Note: In this example, the text for the `Message` column displays on two lines for three state changes. However, the actual output displays on one line for each of these three state changes.

   ```
   % kubectl describe ttc sample
   Name:         sample
   ...
   Events:
     Type  Reason       Age    From       Message
     ----  ------       ----   ----       -------
     -     StateChange  2m1s   ttclassic  TimesTenClassic sample: was Normal, now
   ActiveDown
     -     StateChange  115s   ttclassic  Pod sample-1 Database Updatable: Yes
     -     StateChange  115s   ttclassic  TimesTenClassic sample:was ActiveDown, now
   StandbyDown
     -     StateChange  115s   ttclassic  Pod sample-1 RepState ACTIVE
     -     StateChange  110s   ttclassic  Pod sample-0 High Level State Unknown
     -     StateChange  63s    ttclassic  Pod sample-0 Pod Phase Running
     -     StateChange  63s    ttclassic  Pod sample-0 Agent Up
   ```

```
  -     StateChange  63s    ttclassic  Pod sample-0 Instance Exists
  -     StateChange  63s    ttclassic  Pod sample-0 Daemon Up
  -     StateChange  63s    ttclassic  Pod sample-0 Database None
  -     StateChange  42s    ttclassic  Pod sample-0 Database Loaded
  -     StateChange  42s    ttclassic  Pod sample-0 Database Updatable: No
  -     StateChange  42s    ttclassic  Pod sample-0 RepAgent Running
  -     StateChange  42s    ttclassic  Pod sample-0 CacheAgent Not Running
  -     StateChange  42s    ttclassic  Pod sample-0 RepScheme Exists
  -     StateChange  42s    ttclassic  Pod sample-0 RepState IDLE
  -     StateChange  36s    ttclassic  Pod sample-0 High Level State Healthy
  -     StateChange  36s    ttclassic  Pod sample-0 RepState STANDBY
  -     StateChange  36s    ttclassic  TimesTenClassic sample:was StandbyDown,now
Normal
```

Kubernetes has automatically respawned a new `sample-0` Pod to replace the Pod you deleted. The Operator configured TimesTen within that Pod, bringing the database in the Pod up as the new standby database. The replicated pair of databases are once again functioning normally.

17 Perform Upgrades

The TimesTen Kubernetes Operator provides support for upgrading TimesTen CRDs, the TimesTen Operator, and TimesTen Classic databases to a new patch or patch set.

The TimesTen Operator provides YAML manifest files and Helm charts for upgrading TimesTen CRDs and the TimesTen Operator. You obtain these files from TimesTen container images.

The TimesTen Operator also provides support for upgrading replicated and non-replicated TimesTen Classic databases that are deployed in your Kubernetes namespace. For each replicated or non-replicated configuration, you have the option of choosing a manual or automated upgrade strategy. The processes and procedures differ depending on your configuration and upgrade strategy.

This chapter discusses and details the upgrade processes and procedures using YAML manifest files. If you are using Helm charts, see Use Helm in Your TimesTen Kubernetes Operator Environment.

Topics include:

About Obtaining Container Images for the Upgrade

The TimesTen Operator provides several options for obtaining container images that contain the release of TimesTen that you want to use for the upgrade. These container images contain the YAML manifest files and Helm charts that are necessary to upgrade the TimesTen CRDs and the TimesTen Operator. For detailed information about your options, see Prepare to Use the TimesTen Kubernetes Operator.

The examples in this chapter assume you have made the following decisions:

- Container image: The container image that contains the new release of TimesTen is `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

- Download directories: The directories on your development host that contain the YAML manifest files and Helm charts for the upgrade are `new_kube_files/deploy` and `new_kube_files/helm` respectfully.

About Upgrading from Previous Releases

In TimesTen releases `22.1.1.27.0` and greater, the TimesTenClassic Custom Resouce Definition (CRD) defines different schema versions. The TimesTen Operator supports the creation, monitoring, and management of TimesTenClassic objects in these schema versions. For more information about TimesTen CRDs, see About the TimesTenClassic CRD.

In TimesTen releases `22.1.1.27.0` and greater, note the following:

- You can create TimesTenClassic objects in different schema versions. However, to use attributes specific to the latest release of the TimesTen Operator, you must define your object with the `v4` schema definitions. For information about these attributes, see TimesTenClassicSpecSpec.
- Kubernetes uses the `v4` schema version as the default version. If you use the `kubectl get` command to fetch a TimesTenClassic object, Kubernetes returns the object in `v4` format, unless you explicitly ask for a different format.
- Not only does Kubernetes support multiple versions of a CRD simultaneously, but it can serve an object in a schema version that is different than the one in which it was created. A TimesTenClassic object that you created with one schema version can be fetched with another schema version. For example, you can create a `v4` TimesTenClassic object and can fetch it as a different version of the object.
- Kubernetes stores newly created objects using one schema version. Kubernetes stores TimesTenClassic objects in the `v4` schema.
- Use the following syntax to define `v4` TimesTenClassic objects:

  ```
  apiVersion: timesten.oracle.com/v4
  kind: TimesTenClassic
  ```

  Using `timesten.oracle.com/v4` for `apiVersion` instructs Kubernetes to create a `v4` object. For more information about `apiVersion`, see TimesTenClassic.

Upgrade the TimesTen CRD

You can upgrade the TimesTen CRD that is installed in your Kubernetes cluster. In TimesTen releases `22.1.1.27.0` and greater, the TimesTenClassic CRD contains different schema versions. The `v4` schema version is the most current. The `v4` and `v3` schema versions are available to facilitate compatibility with previous releases of the TimesTen Operator. The `v3` schema version is deprecated and will be removed in a future release. For more information, see About Upgrading from Previous Releases.

Note the following:

- You cannot downgrade a TimesTen CRD.
- Since CRDs are cluster-scoped, if you delete a TimesTen CRD from your Kubernetes cluster, all TimesTenClassic objects that are deployed in this cluster are also deleted.

This example uses YAML manifest files for the upgrade. To use Helm charts, see Use Helm in Your TimesTen Kubernetes Operator Environment.

1. On your development host, change to the directory that contains the YAML manifest files for the upgrade. In this example, change to the `new_kube_files/deploy` directory.

   ```
   cd new_kube_files/deploy
   ```

2. Replace the TimesTen CRD that is installed in your Kubernetes cluster.

   ```
   kubectl replace -f crd.yaml
   ```

   The output is the following:

   ```
   customresourcedefinition.apiextensions.k8s.io/
   timestenclassics.timesten.oracle.com replaced
   ```

Congratulations! You successfully upgraded the TimesTen CRD.

About Upgrading the TimesTen Operator

Before you begin the upgrade of the TimesTen Operator, ensure you have obtained either the YAML manifest files or the Helm charts necessary for the upgrade. See About Obtaining Container Images for the Upgrade. If you are using Helm charts for the upgrade, see Overview of Helm and TimesTen Helm Charts.

The upgrade process differs depending on whether you are upgrading the TimesTen Operator in one or more namespaces at namespace-scope or in the `timesten-operator` namespace at cluster-scope. You must upgrade the TimesTen Operator in the same scope as the scope in which you installed the TimesTen Operator. For more information about the TimesTen Operator scopes, see About the TimesTen Operator.

The following sections show you how to perform the upgrade in both scopes using YAML manifest files. The examples assume the files are located in the `new_kube_files/deploy` directory. See About Obtaining Container Images for the Upgrade.

To upgrade the TimesTen Operator in one or more namespaces in your Kubernetes cluster at namespace-scope, use the following files:

- `service_account.yaml`: Upgrades the service account, role, and role binding objects associated with the TimesTen Operator.

  To perform the upgrade, you use `kubectl replace` to replace the file in your namespace.
- `service_account_cluster.yaml`: Upgrades additional privileges and permissions for the TimesTen Operator. If you installed this file, you must upgrade it. See About Installing the TimesTen Operator.

  You must modify this file and then upgrade it by using `kubectl replace`. The modifications you need to make are explained later in the examples.
- `operator.yaml`: Upgrades the TimesTen Operator in a namespace in your Kubernetes cluster at namespace-scope.

  You must modify this file and then upgrade it by using `kubectl replace`. The modifications you need to make are explained later in the examples.

To upgrade the TimesTen Operator in the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope, use the following files:

- `cluster_config.yaml`: Upgrades the `timesten-operator` namespace as well as the ServiceAccount, Role, RoleBinding, ClusterRole, and ClusterRoleBinding objects necessary to run the TimesTen Operator in the `timesten-operator` namespace at cluster-scope.

To perform the upgrade, you use `kubectl replace` to replace the file.

- `cluster_operator.yaml`: Upgrades the TimesTen Operator in the `timesten-operator` namespace in your cluster at cluster-scope.

  You must modify this file and then upgrade it by using `kubectl replace`. The modifications you need to make are explained later in the examples.

Upgrade the TimesTen Operator

Let's walk through some examples that show you how to upgrade the TimesTen Operator in two namespaces in a Kubernetes cluster at namespace-scope and in the `timesten-operator` namespace in a Kubernetes cluster at cluster-scope.

- Upgrade the TimesTen Operator at Namespace-Scope
- Upgrade the TimesTen Operator at Cluster-Scope

Upgrade the TimesTen Operator at Namespace-Scope

The examples in this section assume you have obtained the YAML manifest files for the upgrade. See About Obtaining Container Images for the Upgrade. If you are using Helm charts for the upgrade, see Overview of Helm and TimesTen Helm Charts.

There is one example for upgrading the TimesTen Operator in one namespace in your cluster at namespace-scope. There is a second example for upgrading the TimesTen Operator into a second namespace in your cluster at namespace-scope. The examples illustrate that you must upgrade the TimesTen Operator in each namespace. Once upgraded, the TimesTen Operator that you upgraded in namespace one services TimesTenClassic objects in namespace one while the TimesTen Operator that you upgraded in namespace two services TimesTenClassic objects in namespace two.

To complete the upgrade, perform the steps in the following sections:

- Before You Begin
- Upgrade in Namespace One
- Upgrade in Namespace Two

Before You Begin

Let's confirm the namespaces in which the TimesTen Operator is running.

1. Confirm the namespaces.

   ```
   kubectl get namespaces
   ```

   The output is similar to the following:

   ```
   kubectl get namespaces
   NAME              STATUS   AGE
   mynamespace       Active   15d
   mynamespace2      Active   10d
   ```

2. Determine the namespaces in which the TimesTen Operator is running.

   ```
   kubectl get pods -l name=timesten-operator -A
   ```

   The output is similar to the following:

   ```
   NAMESPACE      NAME                                READY   STATUS
   RESTARTS   AGE
   mynamespace    timesten-operator-577f7fbc6f-f7588   1/1     Running
   0          10d
   mynamespace2   timesten-operator-577f7fbc6f-pgclv   1/1     Running
   0          10d
   ```

   There are two TimesTen Operators. One Operator is running in the `mynamespace` namespace and a second Operator is running in the `mynamespace2` namespace. Each TimesTen Operator is running at namespace-scope.

Upgrade in Namespace One

Let's upgrade the TimesTen Operator in the `mynamespace` namespace at namespace-scope.

1. Switch to namespace one (`mynamespace`, in this example).

   ```
   kubectl config set-context --current --namespace=mynamespace
   ```

   The output is similar to the following:

   ```
   Context "default" modified.
   ```

2. Confirm a TimesTen Operator is running in this namespace.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                                          READY
   STATUS    RESTARTS   AGE
   ...
   timesten-operator-577f7fbc6f-tbr7m                            1/1
   Running   0          10d
   ...
   ```

3. Change to the directory that contains the YAML manifest files for the upgrade. In this example, the `new_kube_files/deploy` directory contains the files.

   ```
   cd new_kube_files/deploy
   ```

4. Upgrade the service account, role, and role binding objects.

   ```
   kubectl replace -f service_account.yaml
   ```

The output is similar to the following:

```
role.rbac.authorization.k8s.io/timesten-operator replaced
serviceaccount/timesten-operator replaced
rolebinding.rbac.authorization.k8s.io/timesten-operator replaced
```

5. Make a copy of the `service_account_cluster.yaml` file for the first namespace (`service_account_cluster_n1.yaml`, in this example).

   ```
   cp service_account_cluster.yaml service_account_cluster_n1.yaml
   ```

6. Replace the `service_account_cluster_n1.yaml` YAML file by doing the following:
   a. (Optional): Display the contents of the `service_account_cluster_n1.yaml` file.

      ```
      cat service_account_cluster_n1.yaml
      ```

      The output is similar to the following:

      ```
      # Copyright (c) 2025, Oracle and/or its affiliates.
      apiVersion: rbac.authorization.k8s.io/v1
      kind: ClusterRole
      metadata:
        name: timesten-operator
        # If running multiple operators on the same cluster:
        #name: timesten-operator-<NAMESPACE>
      rules:
      - apiGroups:
        - ""
        resources:
        - nodes
        verbs:
        - get
        - list
        - watch
      - apiGroups:
        - ""
        resources:
        - persistentvolumeclaims
        verbs:
        - get
        - list
        - watch
        - delete
      ---
      kind: ClusterRoleBinding
      apiVersion: rbac.authorization.k8s.io/v1
      metadata:
        name: timesten-operator
        # If running multiple operators on the same cluster:
        #name: timesten-operator-<NAMESPACE>
      subjects:
      - kind: ServiceAccount
        name: timesten-operator
        #namespace: <NAMESPACE>
      roleRef:
      ```

```
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
  apiGroup: rbac.authorization.k8s.io
```

b. Use a text editor to modify the `service_account_cluster_n1.yaml` file.

Make the following changes:

- Locate `#namespace`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace`, in this example).
- Locate the three occurrences of `#name`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace`, in this example).

```
vi service_account_cluster_n1.yaml

# Copyright (c) 2025, Oracle and/or its affiliates.
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace
rules:
- apiGroups:
  - ""
  resources:
  - nodes
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - persistentvolumeclaims
  verbs:
  - get
  - list
  - watch
  - delete
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace
subjects:
- kind: ServiceAccount
  name: timesten-operator
  namespace: mynamespace
roleRef:
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace
  apiGroup: rbac.authorization.k8s.io
```

c. Save and close the `service_account_cluster_n1.yaml` file.

d. Replace the `service_account_cluster_n1.yaml` file.

```
kubectl replace -f service_account_cluster_n1.yaml
```

The output is similar to the following:

```
clusterrole.rbac.authorization.k8s.io/timesten-operator-mynamespace
replaced
clusterrolebinding.rbac.authorization.k8s.io/timesten-operator-
mynamespace replaced
```

7. Modify the `operator.yaml` file by doing the following:

a. Use a text editor to modify the `operator.yaml` file.

Replace the following:

- `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.2.0` with the name of the image for the upgrade. In this example, the name of the image for the upgrade is `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.
- If you are running in a multi-architecture environment, modify the `affinity` section, using the same setting you used during installation. This example uses `amd64`.

```
vi operator.yaml

# Copyright (c) 2019 - 2025, Oracle and/or its affiliates.
apiVersion: apps/v1
kind: Deployment
metadata:
  name: timesten-operator
spec:
  replicas: 1
...
    spec:
      serviceAccountName: timesten-operator
      imagePullSecrets:
      - name: sekret
      containers:
        - name: timesten-operator
          image: container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
...
# An example affinity definition; this pod will only be assigned to a
node
# running on amd64 (the default)
#
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                - key: "kubernetes.io/arch"
                  operator: In
                  values: ["amd64"]
```

   b. Save and close the `operator.yaml` file.

8. Upgrade the TimesTen Operator.

```
kubectl replace -f operator.yaml
```

   The output is the following:

```
deployment.apps/timesten-operator replaced
```

9. Verify the TimesTen Operator is running.

```
kubectl get pods
```

   The output is similar to the following:

```
NAME                                                         READY
STATUS    RESTARTS   AGE
...
timesten-operator-7fb9bddf-xrc8h                             1/1
Running   0          41s
...
```

10. (Optional) Verify the TimesTen Operator is running the new image.

```
kubectl describe deployment timesten-operator | grep Image
```

   The output is the following:

```
Image:        container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

Congratulations! You successfully upgraded the TimesTen Operator in the `mynamespace` namespace at namespace-scope. The Operator is using the `container-registry.oracle.com/timesten/timesten:26.1.1.2.0` image and is automatically managing any existing TimesTenClassic objects in this namespace.

If you are upgrading the TimesTen Operator in a second namespace at namespace-scope, proceed to Upgrade in Namespace Two. If you are ready to upgrade TimesTenClassic objects in the `mynamespace` namespace, proceed to About Upgrading TimesTen Classic Databases.

Upgrade in Namespace Two

Let's upgrade the TimesTen Operator in the `mynamespace2` namespace at namespace-scope.

1. Switch to namespace two (`mynamespace2`, in this example).

```
kubectl config set-context --current --namespace=mynamespace2
```

The output is similar to the following:

```
Context "default" modified.
```

2. Confirm a TimesTen Operator is running in this namespace.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                 READY   STATUS    RESTARTS   AGE
   ...
   timesten-operator-577f7fbc6f-h8hj8   1/1     Running   0          12d
   ...
   ```

3. Change to the directory that contains the YAML manifest files for the upgrade. In this example, the `new_kube_files/deploy` directory contains the files.

   ```
   cd new_kube_files/deploy
   ```

4. Replace the required service account, role, and role binding.

   ```
   kubectl replace -f service_account.yaml
   ```

   The output is similar to the following:

   ```
   role.rbac.authorization.k8s.io/timesten-operator replaced
   serviceaccount/timesten-operator replaced
   rolebinding.rbac.authorization.k8s.io/timesten-operator replaced
   ```

5. Make a copy of the `service_account_cluster.yaml` file for the namespace (`service_account_cluster_n2.yaml`, in this example).

   ```
   cp service_account_cluster.yaml service_account_cluster_n2.yaml
   ```

6. Replace the `service_account_cluster_n2.yaml` YAML file by doing the following:

   a. (Optional): Display the contents of the `service_account_cluster_n2.yaml` file.

      ```
      cat service_account_cluster_n2.yaml
      ```

      The output is similar to the following:

      ```
      # Copyright (c) 2025, Oracle and/or its affiliates.
      apiVersion: rbac.authorization.k8s.io/v1
      kind: ClusterRole
      metadata:
        name: timesten-operator
        # If running multiple operators on the same cluster:
        #name: timesten-operator-<NAMESPACE>
      rules:
      - apiGroups:
        - ""
        resources:
      ```

```
  - nodes
  verbs:
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - persistentvolumeclaims
  verbs:
  - get
  - list
  - watch
  - delete
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
subjects:
- kind: ServiceAccount
  name: timesten-operator
  #namespace: <NAMESPACE>
roleRef:
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  #name: timesten-operator-<NAMESPACE>
  apiGroup: rbac.authorization.k8s.io
```

b. Use a text editor to modify the `service_account_cluster_n2.yaml` file.

Make the following changes:

- Locate `#namespace`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace2`, in this example).
- Locate the three occurrences of `#name`, remove `#`, and replace `<NAMESPACE>` with the name of your namespace (`mynamespace2`, in this example).

```
vi service_account_cluster_n2.yaml

# Copyright (c) 2025, Oracle and/or its affiliates.
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace2
rules:
- apiGroups:
  - ""
  resources:
  - nodes
  verbs:
```

```
  - get
  - list
  - watch
- apiGroups:
  - ""
  resources:
  - persistentvolumeclaims
  verbs:
  - get
  - list
  - watch
  - delete
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace2
subjects:
- kind: ServiceAccount
  name: timesten-operator
  namespace: mynamespace2
roleRef:
  kind: ClusterRole
  name: timesten-operator
  # If running multiple operators on the same cluster:
  name: timesten-operator-mynamespace2
  apiGroup: rbac.authorization.k8s.io
```

c. Save and close the `service_account_cluster_n2.yaml` file.

d. Replace the `service_account_cluster_n2.yaml` file.

```
kubectl replace -f service_account_cluster_n2.yaml
```

The output is similar to the following:

```
clusterrole.rbac.authorization.k8s.io/timesten-operator-mynamespace2
replaced
clusterrolebinding.rbac.authorization.k8s.io/timesten-operator-
mynamespace2 replaced
```

7. Modify the `operator.yaml` file by doing the following:

   a. Use a text editor to modify the `operator.yaml` file.

   Replace the following:

   - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.2.0` with the name of the image for the upgrade. In this example, the name of the image for the upgrade is `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

- If you are running in a multi-architecture environment, modify the `affinity` section, using the same setting you used during installation. This example uses `amd64`.

```
vi operator.yaml

# Copyright (c) 2019 - 2025, Oracle and/or its affiliates.
apiVersion: apps/v1
kind: Deployment
metadata:
  name: timesten-operator
spec:
  replicas: 1
...
    spec:
      serviceAccountName: timesten-operator
      imagePullSecrets:
      - name: sekret
      containers:
        - name: timesten-operator
          image: container-registry.oracle.com/timesten/
timesten:26.1.1.2.0
...
# An example affinity definition; this pod will only be assigned to a
node
# running on amd64 (the default)
#
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
              - matchExpressions:
                - key: "kubernetes.io/arch"
                  operator: In
                  values: ["amd64"]
```

b. Save and close the `operator.yaml` file.

8. Upgrade the TimesTen Operator.

```
kubectl replace -f operator.yaml
```

The output is the following:

```
deployment.apps/timesten-operator replaced
```

9. Verify the TimesTen Operator is running.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                    READY   STATUS    RESTARTS   AGE
...
```

```
timesten-operator-c4b99bd8f-smjlm   1/1     Running   0          43s
...
```

10. (Optional) Verify the TimesTen Operator is running the new image.

    ```
    kubectl describe deployment timesten-operator | grep Image
    ```

    The output is the following:

    ```
    Image:        container-registry.oracle.com/timesten/timesten:26.1.1.2.0
    ```

Congratulations! You successfully upgraded the TimesTen Operator in the mynamespace2 namespace at namespace-scope. The Operator is using the container-registry.oracle.com/timesten/timesten:26.1.1.2.0 image and is automatically managing any existing TimesTenClassic objects in this namespace.

To upgrade TimesTenClassic objects in the mynamespace2 namespace, proceed to About Upgrading TimesTen Classic Databases.

Upgrade the TimesTen Operator at Cluster-Scope

The examples in this section assume you have obtained the YAML manifest files for the upgrade. See About Obtaining Container Images for the Upgrade. If you are using Helm charts for the upgrade, see Overview of Helm and TimesTen Helm Charts.

Let's walk through the steps to upgrade the TimesTen Operator at cluster-scope.

1. Confirm the TimesTen Operator is running at cluster-scope.
    a. Confirm there is a TimesTen Operator running in the timesten-operator namespace.

       ```
       kubectl get pods -l name=timesten-operator -A
       ```

       The output is similar to the following:

       ```
       NAMESPACE           NAME                                 READY
       STATUS    RESTARTS   AGE
       timesten-operator   timesten-operator-6bf76dd84b-c8j59   1/1
       Running   0          2d4h
       ```

       There is a TimesTen Operator running in the timesten-operator namespace.
    b. Verify the TimesTen Operator Deployment has the TT_OPERATOR_SCOPE environment variable set to cluster.

       ```
       kubectl describe deployment timesten-operator -n timesten-operator |
       grep TT_OPERATOR_SCOPE
       ```

       The output is the following:

       ```
             TT_OPERATOR_SCOPE:                 cluster
       ```

2. Change to the directory that contains the YAML manifest files for the upgrade. In this example, the `new_kube_files/deploy` directory contains the files.

   ```
   cd new_kube_files/deploy
   ```

3. Upgrade the service account, cluster role, and cluster rolebinding objects.

   ```
    kubectl replace -f cluster_config.yaml
   ```

   The output is similar to the following:

   ```
   namespace/timesten-operator replaced
   clusterrole.rbac.authorization.k8s.io/timesten-operator replaced
   serviceaccount/timesten-operator replaced
   clusterrolebinding.rbac.authorization.k8s.io/timesten-operator replaced
   ```

4. Modify the `cluster_operator.yaml` file by doing the following:

   a. Use a text editor to modify the `cluster_operator.yaml` file.

      Replace the following:

      - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.2.0` with the name of the image for the upgrade. In this example, the name of the image for the upgrade is `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.
      - If you are running in a multi-architecture environment, modify the `affinity` section, using the same setting you used during installation. This example uses `amd64`.

      ```
      vi cluster_operator.yaml

      # Copyright (c) 2019 - 2025, Oracle and/or its affiliates.
      apiVersion: apps/v1
      kind: Deployment
      metadata:
        name: timesten-operator
      spec:
        replicas: 1
      ...
          spec:
            serviceAccountName: timesten-operator
            imagePullSecrets:
            - name: sekret
            containers:
              - name: timesten-operator
                image: container-registry.oracle.com/timesten/
      timesten:26.1.1.2.0
      ...
      # An example affinity definition; this pod will only be assigned to a
      node
      # running on amd64 (the default)
      #
            affinity:
              nodeAffinity:
                requiredDuringSchedulingIgnoredDuringExecution:
      ```

```
                  nodeSelectorTerms:
                    - matchExpressions:
                      - key: "kubernetes.io/arch"
                        operator: In
                        values: ["amd64"]
```

   b. Save and close the `cluster_operator.yaml` file.

5. Upgrade the TimesTen Operator.

   ```
   kubectl replace -f cluster_operator.yaml
   ```

   The output is the following:

   ```
   deployment.apps/timesten-operator replaced
   ```

6. Verify the TimesTen Operator is running in the `timesten-operator` namespace.

   ```
   kubectl get pods -n timesten-operator
   ```

   The output is similar to the following:

   ```
   NAME                                 READY   STATUS    RESTARTS   AGE
   timesten-operator-5cf4b68d58-5cn6t   1/1     Running   0          54s
   ```

7. (Optional) Verify the TimesTen Operator is running the new image.

   ```
   kubectl describe deployment timesten-operator -n timesten-operator| grep
   Image
   ```

   The output is the following:

   ```
   Image:        container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   ```

Congratulations! You successfully upgraded the TimesTen Operator. The Operator is running in the `timesten-operator` namespace in your Kubernetes cluster at cluster-scope. The Operator is using the `container-registry.oracle.com/timesten/timesten:26.1.1.2.0` image.

If you are ready to upgrade TimesTenClassic objects, proceed to About Upgrading TimesTen Classic Databases.

About Upgrading TimesTen Classic Databases

The TimesTen Operator provides support for upgrading TimesTen Classic databases that are deployed in your Kubernetes namespace. The support is applicable to both replicated and non-replicated configurations. For each configuration, the TimesTen Operator supports an automated and a manual image upgrade strategy. The TimesTen Operator determines the upgrade strategy from the `.spec.ttspec.imageUpgradeStrategy` datum. If the value is `Auto` (or not specified), the upgrade process is automated. If the value is `Manual`, the upgrade process is manual. You have the option of specifying the `.spec.ttspec.imageUpgradeStrategy` datum when you define the attributes for your TimesTenClassic object. See About Defining TimesTenClassic Objects.

The upgrade process is dependent on the configuration and the image upgrade strategy. The upgrade processes are discussed in the following sections:

- About the Upgrade Process for Replicated Configurations
- About the Upgrade Process for Non-Replicated Configurations

About the Upgrade Process for Replicated Configurations

For replicated configurations where the image upgrade strategy is:

- `Auto`: The upgrade process is automated and occurs immediately. Kubernetes takes no explicit action to terminate Pods as part of the upgrade process. Instead, the TimesTen Operator automatically terminates Pods in an orchestrated manner to perform the upgrade.
- `Manual`: The upgrade process is manual. Neither Kubernetes nor the TimesTen Operator takes immediate action. You are responsible for initiating the upgrade.

Note

The following actions occur during both an automated and a manual upgrade:

- The standby is terminated first. It takes some time for the standby to come back up. When the standby comes back up, it is upgraded to the new release. During the upgrade of the standby, depending on your replication configuration, there may be disruption on the active database.
- Next, the failover from the active to the standby occurs:
  - The active is terminated. It takes some time for the former active to come back up. When the active comes back up, it is upgraded to the new release.
  - The standby database is promoted to the active and the former active becomes the standby.

If you are using AWT cache groups, the standby is normally responsible for transmitting committed transactions from TimesTen to the Oracle Database. While the standby is being upgraded, the active takes on this responsibility. This may increase the load on the active. In addition, part of the upgrade process involves copying the database from the active to the standby. This also increases the workload on the active. These increases may temporarily reduce the performance of the active database.

For more information about how TimesTen performs an upgrade of an active standby pair of TimesTen databases, see Performing an Upgrade with Active Standby Pair Replication in the *Oracle TimesTen In-Memory Database Installation, Migration, and Upgrade Guide*.

Ensure you perform an upgrade at the appropriate time. We recommend that you do not perform upgrades at the busiest time of a production day. Applications may experience short outages and perhaps reduced performance as a result of the upgrade procedure.

There are examples later in the chapter that show you how to perform an automated and a manual upgrade for replicated TimesTenClassic objects. The examples are in the following sections:

- Perform an Automated Upgrade of a Replicated TimesTenClassic Object

- Perform a Manual Upgrade of a Replicated TimesTenClassic Object

About the Upgrade Process for Non-Replicated Configurations

For non-replicated configurations where the image upgrade strategy is:

- `Auto`: The upgrade process is automated. The TimesTen Operator does not take immediate action. Rather, Kubernetes takes action and automatically begins terminating Pods and replacing them with new ones. The new Pods run the upgraded TimesTen image.

  The number of Pods that Kubernetes terminates and replaces is dependent on the value of the `.spec.ttspec.rollingUpdatePartition` datum. In particular, Kubernetes upgrades Pods whose ordinal value is greater than or equal to the value of `.spec.ttspec.rollingUpdatePartition`. Pods whose ordinal value is less than the value of `.spec.ttspec.rollingUpdatePartition` are not upgraded. For example, if you have three non-replicated Pods (`replicas = 3` where the ordinal value of the Pods are `-0`, `-1`, and `-2`) and the value of `.spec.ttspec.rollingUpdatePartition` is `2`, the `-2` Pod is upgraded, but the `-1` and `-0` Pods are not. The default for `.spec.ttspec.rollingUpdatePartition` is `0`.

  You have the option of specifying the `.spec.ttspec.rollingUpdatePartition` datum when you define the attributes for your TimesTenClassic object. If you do not specify the datum, the default is `0`. See About Defining TimesTenClassic Objects.

  You also have the option of changing the value of the `.spec.ttspec.rollingUpdatePartition` datum as part of the upgrade procedure. There is an example later in the chapter that illustrates how to do this.
- `Manual`: The upgrade process is manual. Neither Kubernetes nor the TimesTen Operator takes immediate action. You are responsible for initiating the upgrade by deleting one or more Pods. For manual upgrades, the `.spec.ttspec.rollingUpdatePartition` datum is ignored.

There are two examples later in the chapter that show you how to perform an automated and a manual upgrade for non-replicated TimesTenClassic objects. The examples are in the following sections:

- Perform an Automated Upgrade of a Non-Replicated TimesTenClassic Object
- Perform a Manual Upgrade of a Non-Replicated TimesTenClassic Object

Perform an Automated Upgrade of a Replicated TimesTenClassic Object

Before starting the automated upgrade, note the following:

Note

An automated upgrade happens immediately. The TimesTen Operator takes down your databases, restarts them, and then initiates and completes the fail over process. Do not perform this procedure at the busiest time of your production day. Applications see short outages and perhaps reduced performance as a result of the upgrade procedure.

Let's perform an automated upgrade for a replicated TimesTenClassic object.

1. Review the TimesTenClassic objects running in your namespace.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME              STATE             ACTIVE            AGE
   mannorepsample    AllReplicasReady  N/A               30h
   manrepsample      Normal            manrepsample-0    54m
   norepsample       AllReplicasReady  N/A               21h
   repsample         Normal            repsample-0       50m
   ```

   There are several TimesTenClassic objects running in your namespace. One of the replicated TimesTenClassic objects is `repsample`. Its high level state is `Normal` indicating TimesTen databases in the active standby pair are up and running and functioning properly.

2. Review the image upgrade strategy for the object.

   ```
   kubectl get ttc repsample -o yaml | grep imageUpgradeStrategy
   ```

   The output is the following:

   ```
   imageUpgradeStrategy: Auto
   ```

   The image upgrade strategy is `Auto` (also the default), indicating an automated upgrade strategy.

3. On your development host, edit the TimesTenClassic object's `.spec.ttspec.image` datum with the container image you want to use for the upgrade. This example uses `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

   a. Edit the file, replacing the `image` value with `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

      ```
       kubectl edit ttc repsample

      # Please edit the object below. Lines beginning with a '#' will be
      ignored,
      # and an empty file will abort the edit. If an error occurs while
      saving this file will be
      # reopened with the relevant failures.
      #
      apiVersion: timesten.oracle.com/v4
      kind: TimesTenClassic
      ...
          image: container-registry.oracle.com/timesten/timesten:26.1.1.2.0
      ...
      ```

   b. Save the file and exit from the editor.

4. Confirm the StatefulSet contains the new image.

```
kubectl describe statefulset repsample | grep Image
```

The output is the following:

```
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

When the TimesTen Operator detects that there is an update to the TimesTenClassic's `.spec.ttspec.image` datum, it modifies the StatefulSet with the new image. Since this is an automated upgrade of a replicated TimesTenClassic object, the TimesTen Operator takes action and initiates and orchestrates the upgrade process.

5. Monitor the progress of the upgrade, observing the state transitions.

```
kubectl get events -w
```

The output is similar to the following:

```
LAST SEEN   TYPE      REASON                   OBJECT
MESSAGE
...
8m4s        Normal    Upgrade                  timestenclassic/repsample
Image updated, automatic upgrade started
8m4s        Normal    Upgrade                  timestenclassic/repsample
Deleted standby pod repsample-1 during upgrade
7m59s       Warning   Failed                   timestenclassic/repsample
Pod repsample-1 was replaced
7m54s       Normal    StateChange              timestenclassic/repsample
Pod repsample-1 is Not Ready
7m54s       Warning   StateChange              timestenclassic/repsample
TimesTenClassic was Normal, now ActiveTakeover
7m53s       Normal    StateChange              timestenclassic/repsample
TimesTenClassic was ActiveTakeover, now StandbyDown
5m28s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Agent Up
5m28s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Instance Exists
5m28s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Daemon Down
5m28s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Daemon Up
5m28s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Database Unloaded
5m25s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Database None
5m10s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Database Loaded
5m10s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 RepAgent Not Running
5m10s       Normal    Info                     timestenclassic/repsample
```

```
Pod repsample-1 RepScheme Exists
5m10s       Normal    StateChange              timestenclassic/repsample
Pod repsample-1 RepState IDLE
5m4s        Normal    Info                     timestenclassic/repsample
Pod repsample-1 Database Loaded
5m4s        Normal    Info                     timestenclassic/repsample
Pod repsample-1 RepAgent Running
5m4s        Normal    Info                     timestenclassic/repsample
Pod repsample-1 RepScheme Exists
5m4s        Normal    StateChange              timestenclassic/repsample
Pod repsample-1 RepState STANDBY
5m4s        Normal    StateChange              timestenclassic/repsample
Pod repsample-1 is Ready
5m3s        Normal    Upgrade                  timestenclassic/repsample
Upgrade of standby complete
5m3s        Normal    StateChange              timestenclassic/repsample
TimesTenClassic was StandbyDown, now Normal
4m32s       Normal    Upgrade                  timestenclassic/repsample
Deleted active pod repsample-0 during upgrade
3m31s       Warning   Error                    timestenclassic/repsample
Pod repsample-0 Unreachable for 117 seconds
3m31s       Normal    StateChange              timestenclassic/repsample
Pod repsample-0 is Not Ready
3m31s       Normal    StateChange              timestenclassic/repsample
Pod repsample-0 is Not Active Ready
3m31s       Warning   StateChange              timestenclassic/repsample
TimesTenClassic was Normal, now ActiveDown
3m30s       Warning   Failed                   timestenclassic/repsample
Pod repsample-0 was replaced
3m29s       Normal    Info                     timestenclassic/repsample
Pod repsample-1 Database Updatable
3m29s       Normal    StateChange              timestenclassic/repsample
Pod repsample-1 RepState ACTIVE
3m29s       Normal    StateChange              timestenclassic/repsample
Pod repsample-1 is Not Ready
3m29s       Normal    StateChange              timestenclassic/repsample
TimesTenClassic was ActiveDown, now ActiveTakeover
3m25s       Normal    StateChange              timestenclassic/repsample
Pod repsample-1 is Ready
3m25s       Normal    StateChange              timestenclassic/repsample
Pod repsample-1 is Active Ready
3m25s       Normal    StateChange              timestenclassic/repsample
TimesTenClassic was ActiveTakeover, now StandbyDown
2m35s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 Agent Up
2m35s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 Instance Exists
2m35s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 Daemon Down
2m35s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 Daemon Up
2m35s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 Database Unloaded
2m32s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 Database None
2m11s       Normal    Info                     timestenclassic/repsample
```

```
Pod repsample-0 Database Loaded
2m11s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 RepAgent Not Running
2m11s       Normal    Info                     timestenclassic/repsample
Pod repsample-0 RepScheme Exists
2m11s       Normal    StateChange              timestenclassic/repsample
Pod repsample-0 RepState IDLE
2m5s        Normal    Info                     timestenclassic/repsample
Pod repsample-0 Database Loaded
2m5s        Normal    Info                     timestenclassic/repsample
Pod repsample-0 RepAgent Running
2m5s        Normal    Info                     timestenclassic/repsample
Pod repsample-0 RepScheme Exists
2m5s        Normal    StateChange              timestenclassic/repsample
Pod repsample-0 RepState STANDBY
2m5s        Normal    StateChange              timestenclassic/repsample
Pod repsample-0 is Ready
2m5s        Normal    Upgrade                  timestenclassic/repsample
Upgrade of active complete
2m5s        Normal    Upgrade                  timestenclassic/repsample
Upgrade completed in 359 secs
2m4s        Normal    StateChange              timestenclassic/repsample
TimesTenClassic was StandbyDown, now Normal
```

The automated upgrade process completes. The TimesTenClassic object is in the `Normal` state. TimesTen databases are up and running and functioning properly. Active standby pair replication is configured between them.

6. Verify the active and standby databases are running the correct release.
   a. Establish a shell in the active Pod.

      ```
      kubectl exec -it repsample-1 -c tt -- /bin/bash
      ```

   b. Run the TimesTen `ttVersion` utility.

      ```
      ttVersion
      ```

      The output is similar to the following:

      ```
      TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
      2025-01-16T15:16:01Z
        Instance admin: timesten
        Instance home directory: /tt/home/timesten/instances/instance1
        Group owner: timesten
        Daemon home directory: /tt/home/timesten/instances/instance1/info
        PL/SQL enabled.
      ```

   c. Exit from the shell.
   d. Establish a shell in the standby Pod.

      ```
      kubectl exec -it repsample-0 -c tt -- /bin/bash
      ```

e. Run the TimesTen `ttVersion` utility.

```
ttVersion
```

The output is similar to the following:

```
TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
2025-01-16T15:16:01Z
  Instance admin: timesten
  Instance home directory: /tt/home/timesten/instances/instance1
  Group owner: timesten
  Daemon home directory: /tt/home/timesten/instances/instance1/info
  PL/SQL enabled.
```

f. Exit from the shell.

The active and standby databases are running the correct release of TimesTen.

Congratulations! You successfully completed an automated upgrade for a replicated TimesTenClassic object. The active and standby databases are upgraded, running, and fully operational.

Perform a Manual Upgrade of a Replicated TimesTenClassic Object

Let's perform an manual upgrade for a replicated TimesTenClassic object by first modifying the TimesTenClassic object, followed by initiating an upgrade of the standby database, and concluding with initiating the fail over from the active database to the standby:

- Modify a Replicated TimesTenClassic Object
- Upgrade the Standby Database
- Fail Over

Modify a Replicated TimesTenClassic Object

Let's modify a replicated TimesTenClassic object.

1. Review the TimesTenClassic objects running in your namespace.

```
kubectl get ttc
```

The output is similar to the following:

```
NAME              STATE             ACTIVE           AGE
mannorepsample    AllReplicasReady  N/A              30h
manrepsample      Normal            manrepsample-0   54m
norepsample       AllReplicasReady  N/A              21h
repsample         Normal            repsample-0      50m
```

There are several TimesTenClassic objects running in your namespace. One of the replicated TimesTenClassic objects is `manrepsample`. Its high level state is `Normal` indicating TimesTen databases in the active standby pair are up and running and functioning properly.

2. Review the image upgrade strategy for the object.

```
kubectl get ttc manrepsample -o yaml | grep imageUpgradeStrategy
```

   The output is the following:

```
imageUpgradeStrategy: Manual
```

   The image upgrade strategy is `Manual` , indicating a manual upgrade strategy.

3. On your development host, edit the TimesTenClassic object's `.spec.ttspec.image` datum with the container image you want to use for the upgrade. This example uses `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

   a. Edit the file, replacing the `image` value with `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

```
 kubectl edit ttc manrepsample

# Please edit the object below. Lines beginning with a '#' will be
ignored,
# and an empty file will abort the edit. If an error occurs while
saving this file will be
# reopened with the relevant failures.
#
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
...
    image: container-registry.oracle.com/timesten/timesten:26.1.1.2.0
...
```

   b. Save the file and exit from the editor.

4. Confirm the StatefulSet contains the new image.

```
kubectl describe statefulset manrepsample | grep Image
```

   The output is the following:

```
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

   When the TimesTen Operator detects that there is an update to the TimesTenClassic's `.spec.ttspec.image` datum, it modifies the StatefulSet with the new image. Since this is a manual upgrade of a replicated TimesTenClassic object, the TimesTen Operator takes no further action. This enables you to initiate the manual upgrade.

You successfully modified the TimesTenClassic object. Let's continue the manual upgrade by upgrading the standby database.

Upgrade the Standby Database

Perform these steps to upgrade the standby database.

> **Note**
>
> Even though you are upgrading the standby database, depending on your replication configuration, this may result in disruption on your active database. This may impact your applications. Perform the upgrade at the appropriate time.

1. Determine which Pod is the standby.

   ```
   kubectl get ttc manrepsample
   ```

   The output is similar to the following.

   ```
   NAME           STATE     ACTIVE            AGE
   manrepsample   Normal    manrepsample-0    160m
   ```

   Since the `manrepsample-0` Pod is the active, the `manrepsample-1` Pod is the standby.
2. Delete the standby Pod.

   ```
   kubectl delete pod manrepsample-1
   ```

   The output is the following.

   ```
   pod "manrepsample-1" deleted
   ```

   Kubernetes automatically creates a new `manrepsample-1` Pod to replace the deleted Pod. The TimesTen Operator configures the new `manresample-1` Pod as the standby Pod. This new Pod runs the upgraded TimesTen image.
3. Monitor the progress of the upgrade by observing the state transitions.

   ```
    kubectl get events -w
   ```

   The output is similar to the following:

   ```
   LAST SEEN   TYPE      REASON
   OBJECT                         MESSAGE
   ...
   2m51s       Warning   StateChange              timestenclassic/
   manrepsample   TimesTenClassic was Normal, now ActiveTakeover
   2m50s       Normal    StateChange              timestenclassic/
   manrepsample   TimesTenClassic was ActiveTakeover, now StandbyDown
   50s         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Agent Up
   50s         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Instance Exists
   ```

```
50s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 Daemon Down
50s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 Daemon Up
50s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 Database Unloaded
43s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 Database None
22s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 Database Loaded
22s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 RepAgent Not Running
22s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 RepScheme Exists
22s         Normal    StateChange              timestenclassic/
manrepsample   Pod manrepsample-1 RepState IDLE
16s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 Database Loaded
16s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 RepAgent Running
16s         Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-1 RepScheme Exists
16s         Normal    StateChange              timestenclassic/
manrepsample   Pod manrepsample-1 RepState STANDBY
16s         Normal    StateChange              timestenclassic/
manrepsample   Pod manrepsample-1 is Ready
16s         Normal    StateChange              timestenclassic/
manrepsample   TimesTenClassic was StandbyDown, now Normal
```

The TimesTen Operator successfully upgraded the standby database.

You are now ready to fail over from the active database to the standby.

Fail Over

You are now ready to initiate the fail over from the active database to the standby.

Note

During fail over, the TimesTen Operator takes down your active database, and **immediately** fails over to the standby. Do not perform this procedure at the busiest time of your production day. It's best to consider performing this operation during a scheduled production outage.

Before failing over, quiesce your applications on the active database. You can use the TimesTen `ttAdmin -close` and the `ttAdmin -disconnect` commands. See Opening and Closing the Database for User Connections and Disconnecting from a Database in the *Oracle TimesTen In-Memory Database Operations Guide*.

To avoid potential data loss, use the TimesTen `ttRepAdmin -wait` command to wait until replication is caught up, ensuring that transactions that were executed on the active database are replicated to the standby database. See ttRepAdmin in the *Oracle TimesTen In-Memory Database Reference*.

Once the standby is caught up, fail over from the active database to the standby by deleting the active Pod. When you delete the active Pod, the TimesTen Operator automatically detects the failure and promotes the standby database to be the active. Client/server applications that are using the active database are automatically reconnected to the new active database. Transactions in flight are rolled back. Prepared SQL statements do need to be re-prepared by the applications. See About Handling Failover and Recovery for more information.

Let's initiate the fail over.

1. Delete the active Pod.

   ```
   kubectl delete pod manrepsample-0
   ```

   The output is the following.

   ```
   pod "manrepsample-0" deleted
   ```

   Kubernetes automatically creates a new `manrepsample-0` Pod to replace the deleted Pod. The TimesTen Operator configures the new `manresample-0` Pod as the standby Pod. This new Pod runs the upgraded TimesTen image.

2. Monitor the progress of the upgrade, observing the state transitions.

   ```
    kubectl get events -w
   ```

   The output is similar to the following:

   ```
   LAST SEEN   TYPE      REASON
   OBJECT                         MESSAGE
   ...
   37m         Warning   Upgrade                  timestenclassic/
   manrepsample   Image updated, automatic upgrade disabled
   26m         Warning   Failed                   timestenclassic/
   manrepsample   Pod manrepsample-1 was replaced
   26m         Normal    StateChange              timestenclassic/
   manrepsample   Pod manrepsample-1 is Not Ready
   26m         Warning   StateChange              timestenclassic/
   manrepsample   TimesTenClassic was Normal, now ActiveTakeover
   26m         Normal    StateChange              timestenclassic/
   manrepsample   TimesTenClassic was ActiveTakeover, now StandbyDown
   24m         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Agent Up
   24m         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Instance Exists
   24m         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Daemon Down
   24m         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Daemon Up
   24m         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Database Unloaded
   24m         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Database None
   24m         Normal    Info                     timestenclassic/
   manrepsample   Pod manrepsample-1 Database Loaded
   24m         Normal    Info                     timestenclassic/
   ```

```
manrepsample   Pod manrepsample-1 RepAgent Not Running
24m         Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-1 RepScheme Exists
24m         Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-1 RepState IDLE
23m         Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-1 Database Loaded
23m         Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-1 RepAgent Running
23m         Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-1 RepScheme Exists
23m         Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-1 RepState STANDBY
23m         Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-1 is Ready
23m         Normal    StateChange                   timestenclassic/
manrepsample   TimesTenClassic was StandbyDown, now Normal
3m50s       Warning   Failed                        timestenclassic/
manrepsample   Pod manrepsample-0 was replaced
3m44s       Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-0 is Not Ready
3m44s       Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-0 is Not Active Ready
3m44s       Warning   StateChange                   timestenclassic/
manrepsample   TimesTenClassic was Normal, now ActiveDown
3m43s       Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-1 Database Updatable
3m43s       Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-1 RepState ACTIVE
3m43s       Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-1 is Not Ready
3m43s       Normal    StateChange                   timestenclassic/
manrepsample   TimesTenClassic was ActiveDown, now ActiveTakeover
3m38s       Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-1 is Ready
3m38s       Normal    StateChange                   timestenclassic/
manrepsample   Pod manrepsample-1 is Active Ready
3m38s       Normal    StateChange                   timestenclassic/
manrepsample   TimesTenClassic was ActiveTakeover, now StandbyDown
119s        Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 Agent Up
119s        Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 Instance Exists
119s        Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 Daemon Down
118s        Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 Daemon Up
118s        Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 Database Unloaded
111s        Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 Database None
90s         Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 Database Loaded
90s         Normal    Info                          timestenclassic/
manrepsample   Pod manrepsample-0 RepAgent Not Running
90s         Normal    Info                          timestenclassic/
```

```
manrepsample   Pod manrepsample-0 RepScheme Exists
90s          Normal    StateChange              timestenclassic/
manrepsample   Pod manrepsample-0 RepState IDLE
84s          Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-0 Database Loaded
84s          Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-0 RepAgent Running
84s          Normal    Info                     timestenclassic/
manrepsample   Pod manrepsample-0 RepScheme Exists
84s          Normal    StateChange              timestenclassic/
manrepsample   Pod manrepsample-0 RepState STANDBY
84s          Normal    StateChange              timestenclassic/
manrepsample   Pod manrepsample-0 is Ready
84s          Normal    StateChange              timestenclassic/
manrepsample   TimesTenClassic was StandbyDown, now Normal
```

The upgrade process completes.

3. Confirm which Pod is the active.

```
kubectl get ttc manrepsample
```

The output is similar to the following:

```
NAME           STATE    ACTIVE           AGE
manrepsample   Normal   manrepsample-1   3h21m
```

The TimesTen Operator promoted the standby `manrepsample-1` database to be the active. Applications that were connected to the `manrepsample-0` database are automatically reconnected to the `manrepsample-1` database by TimesTen. After a brief outage, the applications can continue to use the database.

4. Verify the active and standby databases are running the correct release.
   a. Establish a shell in the active Pod.

   ```
   kubectl exec -it manrepsample-1 -c tt -- /bin/bash
   ```

   b. Run the TimesTen `ttVersion` utility.

   ```
   ttVersion
   ```

   The output is similar to the following:

   ```
   TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
   2025-01-16T15:16:01Z
     Instance admin: timesten
     Instance home directory: /tt/home/timesten/instances/instance1
     Group owner: timesten
     Daemon home directory: /tt/home/timesten/instances/instance1/info
     PL/SQL enabled.
   ```

   c. Exit from the shell.

d. Establish a shell in the standby Pod.

```
kubectl exec -it manrepsample-0 -c tt -- /bin/bash
```

e. Run the TimesTen `ttVersion` utility.

```
ttVersion
```

The output is similar to the following:

```
TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
2025-01-16T15:16:01Z
  Instance admin: timesten
  Instance home directory: /tt/home/timesten/instances/instance1
  Group owner: timesten
  Daemon home directory: /tt/home/timesten/instances/instance1/info
  PL/SQL enabled.
```

f. Exit from the shell.

The active and standby databases are running the correct release of TimesTen.

Congratulations! You successfully performed a manual upgrade for a replicated TimesTenClassic object. The active and standby databases are upgraded, running, and fully operational.

Perform an Automated Upgrade of a Non-Replicated TimesTenClassic Object

Let's perform an automated upgrade for a non-replicated TimesTenClassic object consisting of three independent TimesTen databases.

1. Review the TimesTenClassic objects running in your namespace.

```
kubectl get ttc
```

The output is similar to the following:

```
NAME            STATE            ACTIVE        AGE
mannorepsample  AllReplicasReady N/A           3h47m
norepsample     AllReplicasReady N/A           4d10s
repsample       Normal           repsample-0   5d23h
```

One of the non-replicated TimesTenClassic objects is `norepsample`. Its high level state is `AllReplicasReady`, indicating all replicas are ready and available. TimesTen databases are up and running and functioning properly.

2. Review the image upgrade strategy and rolling update partition values for the object.

```
kubectl get ttc norepsample -o yaml | grep 'imageUpgradeStrategy\|
rollingUpdatePartition'
```

The output is the following:

```
imageUpgradeStrategy: Auto
rollingUpdatePartition: 2
```

The image upgrade strategy is `Auto` (also the default), indicating an automated upgrade strategy. The value for `rollingUpdatePartition` is `2`, indicating that Kubernetes upgrades Pods with an ordinal value greater than or equal to `2`. For the `norepsample` object, since the value of `replicas` is `3`, there are three Pods named `norepsample-0`, `norepsample-1`, and `norepsample-2`. Therefore, Kubernetes only upgrades the `norepsample-2` Pod. Let's verify this by performing the upgrade.

3. On your development host, edit the TimesTenClassic object's `.spec.ttspec.image` datum with the container image you want to use for the upgrade. This example uses `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.
   a. Edit the file, replacing the `image` value with `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

      ```
       kubectl edit ttc norepsample

      # Please edit the object below. Lines beginning with a '#' will be
      ignored,
      # and an empty file will abort the edit. If an error occurs while
      saving this file will be
      # reopened with the relevant failures.
      #
      apiVersion: timesten.oracle.com/v4
      kind: TimesTenClassic
      ...
          image: container-registry.oracle.com/timesten/timesten:26.1.1.2.0
      ...
      ```

   b. Save the file and exit from the editor.
4. Confirm the StatefulSet contains the new image.

   ```
   kubectl describe statefulset norepsample | grep Image
   ```

   The output is the following:

   ```
   Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   ```

   When the TimesTen Operator detects that there is an update to the TimesTenClassic's `.spec.ttspec.image` datum, it modifies the StatefulSet with the new image. Since this is an automated upgrade, the TimesTen Operator takes no further action, but Kubernetes does take action. Kubernetes automatically begins to terminate Pods and replace them with new ones. These new Pods run the new image. Since `rollingUpdatePartition` is `2`, you should expect to see only the `norepsample-2` Pod upgraded with the new image.

5. Monitor the progress.

```
kubectl get ttc norepsample
```

   The output is similar to the following:

```
NAME          STATE              ACTIVE   AGE
norepsample   SomeReplicasReady  N/A      16m
```

   The object is in the `SomeReplicasReady` state.

   Wait a few minutes. Then, monitor again.

```
kubectl get ttc norepsample
```

   The output is similar to the following:

```
NAME          STATE             ACTIVE   AGE
norepsample   AllReplicasReady  N/A      19m
```

   The object is in the `AllReplicasReady` state. All replicas are ready and available. TimesTen databases are up and running and functioning properly.

6. Check the image that the `norepsample-2` Pod is running.

```
kubectl describe pod norepsample-2 | grep Image
```

   The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

   The containers in the Pod are running the new container image.

7. Check the image for the `norepsample-1` and `norepsample-0` Pods.

   a. Check the `norepsample-1` Pod.

```
kubectl describe pod norepsample-1 | grep Image
```

      The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
```

The containers in the Pod are not running the new image. Due to the `rollingUpdatePartition` value of `2`, Kubernetes does not upgrade this Pod with the new image. This is correct behavior.

b. Check the `norepsample-0` Pod.

```
kubectl describe pod norepsample-0 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
Image:          container-registry.oracle.com/timesten/
timesten:26.1.1.1.0
```

The containers in the Pod are not running the new image. Due to the `rollingUpdatePartition` value of `2`, Kubernetes does not upgrade this Pod with the new image. This is correct behavior.

After you confirm the upgrade is working, you can upgrade the remaining Pods.

8. Edit the TimesTenClassic object's `.spec.ttspec.rollingUpdatePartition` datum and change the value from `2` to `0`.

   a. Edit the file, replacing the `rollingUpdatePartition` value with `2`.

   ```
    kubectl edit ttc norepsample

   # Please edit the object below. Lines beginning with a '#' will be
   ignored,
   # and an empty file will abort the edit. If an error occurs while
   saving this file will be
   # reopened with the relevant failures.
   #
   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   ...
       rollingUpdatePartition: 0
   ...
   ```

   b. Save the file and exit from the editor.

   Kubernetes automatically begins to terminate Pods and replace them with new ones. These new Pods run the new image. Since `rollingUpdatePartition` is now `0`, you should expect to see the `norepsample-1` and `norepsample-0` Pods upgraded with the new image.

9. Monitor the progress.

   a. TimesTenClassic object:

   ```
   kubectl get ttc norepsample
   ```

The output is similar to the following

```
NAME          STATE              ACTIVE   AGE
norepsample   SomeReplicasReady  N/A      51m
```

b. Pods:

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                   READY   STATUS     RESTARTS   AGE
...
norepsample-0                          3/3     Running    0          53m
norepsample-1                          0/3     Init:0/1   0          106s
norepsample-2                          3/3     Running    0          36m
```

Kubernetes replaces the `norepsample-1` Pod first. Wait a few minutes. Then monitor again.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                   READY   STATUS     RESTARTS   AGE
...
norepsample-0                          0/3     Init:0/1   0          46s
norepsample-1                          3/3     Running    0          3m41s
norepsample-2                          3/3     Running    0          38m
```

Kubernetes replaced the `norepsample-1` Pod and is in the process of replacing the `norepsample-0` Pod.

Check again.

```
kubectl get pods
```

The output is similar to the following:

```
NAME                                   READY   STATUS    RESTARTS   AGE
...
norepsample-0                          3/3     Running   0          5m59s
norepsample-1                          3/3     Running   0          8m54s
norepsample-2                          3/3     Running   0          43m
```

All Pods are running.

10. Confirm the Pods are running the new container image.

Pod `norepsample-1`:

```
kubectl describe pod norepsample-1 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

Pod `norepsample-0`:

```
kubectl describe pod norepsample-0 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

The Pods are running the new image.

11. (Optional) Confirm the state of the TimesTenClassic object.

```
kubectl get ttc norepsample
```

The output is similar to the following:

```
NAME          STATE              ACTIVE   AGE
norepsample   AllReplicasReady   N/A      62m
```

12. Verify the databases are running the correct release.
    a. Establish a shell in the `-0` Pod.

    ```
    kubectl exec -it norepsample-0 -c tt -- /bin/bash
    ```

    b. Run the TimesTen `ttVersion` utility.

    ```
    ttVersion
    ```

    The output is similar to the following:

    ```
    TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
    2025-01-16T15:16:01Z
      Instance admin: timesten
      Instance home directory: /tt/home/timesten/instances/instance1
      Group owner: timesten
      Daemon home directory: /tt/home/timesten/instances/instance1/info
      PL/SQL enabled.
    ```

    c. Exit from the shell.

d. Establish a shell in the `-1` Pod.

   ```
   kubectl exec -it norepsample-1 -c tt -- /bin/bash
   ```

e. Run the TimesTen `ttVersion` utility.

   ```
   ttVersion
   ```

   The output is similar to the following:

   ```
   TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
   2025-01-16T15:16:01Z
     Instance admin: timesten
     Instance home directory: /tt/home/timesten/instances/instance1
     Group owner: timesten
     Daemon home directory: /tt/home/timesten/instances/instance1/info
     PL/SQL enabled.
   ```

f. Exit from the shell.

g. Establish a shell in the `-2` Pod.

   ```
   kubectl exec -it norepsample-2 -c tt -- /bin/bash
   ```

h. Run the TimesTen `ttVersion` utility.

   ```
   ttVersion
   ```

   The output is similar to the following:

   ```
   TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
   2025-01-16T15:16:01Z
     Instance admin: timesten
     Instance home directory: /tt/home/timesten/instances/instance1
     Group owner: timesten
     Daemon home directory: /tt/home/timesten/instances/instance1/info
     PL/SQL enabled.
   ```

i. Exit from the shell.

The TimesTen databases are running the correct release of TimesTen.

Congratulations! You successfully performed an automated upgrade for a non-replicated TimesTenClassic object. All replicas are ready and available. Pods are running the new TimesTen container image. TimesTen databases are upgraded and fully operational.

Perform a Manual Upgrade of a Non-Replicated TimesTenClassic Object

Let's perform a manual upgrade for a non-replicated TimesTenClassic object consisting of three independent TimesTen databases.

1. Review the TimesTenClassic objects running in your namespace.

   ```
   kubectl get ttc
   ```

   The output is similar to the following:

   ```
   NAME              STATE              ACTIVE        AGE
   mannorepsample    AllReplicasReady   N/A           3m32s
   norepsample       AllReplicasReady   N/A           11h
   repsample         Normal             repsample-0   5d19h
   ```

   One of the non-replicated TimesTenClassic objects is `mannorepsample`. Its high level state is `AllReplicasReady`.

2. Review the image upgrade strategy for this object.

   ```
   kubectl get ttc mannorepsample -o yaml | grep imageUpgradeStrategy
   ```

   The output is the following:

   ```
    imageUpgradeStrategy: Manual
   ```

   The image upgrade strategy is `Manual`. Let's perform an upgrade.

3. On your development host, edit the TimesTenClassic object's `.spec.ttspec.image` datum with the container image you want to use for the upgrade. This example uses `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

   a. Edit the file, replacing the `image` value with `container-registry.oracle.com/timesten/timesten:26.1.1.2.0`.

      ```
       kubectl edit ttc mannorepsample

      # Please edit the object below. Lines beginning with a '#' will be
      ignored,
      # and an empty file will abort the edit. If an error occurs while
      saving this file will be
      # reopened with the relevant failures.
      #
      apiVersion: timesten.oracle.com/v4
      kind: TimesTenClassic
      ...
          image: container-registry.oracle.com/timesten/timesten:26.1.1.2.0
      ...
      ```

   b. Save the file and exit from the editor.

   When the TimesTen Operator detects that there is an update to the TimesTenClassic's `.spec.ttspec.image` datum, it modifies the StatefulSet with the new image. Since this is a manual upgrade of a non-replicated object, the TimesTen Operator and Kubernetes take no further action.

4. (Optional) Confirm the StatefulSet contains the new image.

   ```
   kubectl describe statefulset mannorepsample | grep Image
   ```

The output is the following:

```
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:      container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

The containers including `tt`, `daemonlog`, and `exporter` contain the new image.

5. Review the Pods for the TimesTenClassic object.

   ```
   kubectl get pods
   ```

   The output is similar to the following:

   ```
   NAME                                  READY   STATUS    RESTARTS   AGE
   mannorepsample-0                      3/3     Running   0          26m
   mannorepsample-1                      3/3     Running   0          26m
   mannorepsample-2                      3/3     Running   0          26m
   ...
   ```

   There are three Pods associated with the TimesTenClassic object. Each Pod is running a TimesTen database. The databases are independent and have no relationship to each other.

6. Delete the `mannorepsample-2` Pod. This action causes Kubernetes to terminate the Pod and replace it with a new one.

   ```
   kubectl delete pod mannorepsample-2
   ```

7. Monitor the progress.

   ```
   kubectl get ttc mannorepsample
   ```

   The output is the following:

   ```
   NAME             STATE              ACTIVE   AGE
   mannorepsample   SomeReplicasReady  N/A      49m
   ```

   The object is in the `SomeReplicasReady` state.

   Wait a few minutes. Then monitor again.

   ```
   kubectl get ttc mannorepsample
   ```

   The output is the following:

   ```
   NAME             STATE             ACTIVE   AGE
   mannorepsample   AllReplicasReady  N/A      53m
   ```

   The object is in the `AllReplicasReady` state. All replicas are ready and available. TimesTen databases are up and running and functioning properly.

8. Check the image that the `mannorepsample-2` Pod is running.

   ```
   kubectl describe pod mannorepsample-2 | grep Image
   ```

   The output is similar to the following:

   ```
   Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
   ```

   The containers in the Pod are running the new container image.

9. Delete the remaining Pods.

   ```
   kubectl delete pod mannorepsample-1
   ```

   ```
   kubectl delete pod mannorepsample-0
   ```

10. Monitor the progress.

    ```
    kubectl get pods
    ```

    The output is similar to the following:

    ```
    NAME                                 READY   STATUS     RESTARTS   AGE
    mannorepsample-0                     0/3     Init:0/1   0          13s
    mannorepsample-1                     0/3     Init:0/1   0          60s
    ...
    ```

    Kubernetes starts recreating the Pods.

    Wait a few minutes. Then monitor again.

    ```
    kubectl get pods
    ```

    The output is the following:

    ```
    NAME                                 READY   STATUS    RESTARTS   AGE
    mannorepsample-0                     3/3     Running   0          1m16s
    mannorepsample-1                     3/3     Running   0          2m3s
    mannorepsample-2                     3/3     Running   0          6m32s
    ...
    ```

    The `mannorepsample-0` and `mannorepsample-1` Pods are now running. The `mannorepsample-2` has already been running.

11. Confirm the Pods are running the new container image.

    Pod `mannorepsample-0`:

    ```
    kubectl describe pod mannorepsample-0 | grep Image
    ```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

Pod `mannorepsample-1`:

```
kubectl describe pod mannorepsample-1 | grep Image
```

The output is similar to the following:

```
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
Image:          container-registry.oracle.com/timesten/timesten:26.1.1.2.0
```

The Pods are running the new image.

12. (Optional) Confirm the state of the TimesTenClassic object.

```
kubectl get ttc mannorepsample
```

The output is similar to the following:

```
NAME             STATE              ACTIVE   AGE
mannorepsample   AllReplicasReady   N/A      79m
```

13. Verify the databases are running the correct release.
    a. Establish a shell in the `-0` Pod.

    ```
    kubectl exec -it mannorepsample-0 -c tt -- /bin/bash
    ```

    b. Run the TimesTen `ttVersion` utility.

    ```
    ttVersion
    ```

    The output is similar to the following:

    ```
    TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
    2025-01-16T15:16:01Z
      Instance admin: timesten
      Instance home directory: /tt/home/timesten/instances/instance1
      Group owner: timesten
      Daemon home directory: /tt/home/timesten/instances/instance1/info
      PL/SQL enabled.
    ```

    c. Exit from the shell.

d. Establish a shell in the `-1` Pod.

```
kubectl exec -it mannorepsample-1 -c tt -- /bin/bash
```

e. Run the TimesTen `ttVersion` utility.

```
ttVersion
```

The output is similar to the following:

```
TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
2025-01-16T15:16:01Z
  Instance admin: timesten
  Instance home directory: /tt/home/timesten/instances/instance1
  Group owner: timesten
  Daemon home directory: /tt/home/timesten/instances/instance1/info
  PL/SQL enabled.
```

f. Exit from the shell.

g. Establish a shell in the `-2` Pod.

```
kubectl exec -it mannorepsample-2 -c tt -- /bin/bash
```

h. Run the TimesTen `ttVersion` utility.

```
ttVersion
```

The output is similar to the following:

```
TimesTen Release 26.1.1.2.0 (64 bit Linux/x86_64) (instance1:6624)
2025-01-16T15:16:01Z
  Instance admin: timesten
  Instance home directory: /tt/home/timesten/instances/instance1
  Group owner: timesten
  Daemon home directory: /tt/home/timesten/instances/instance1/info
  PL/SQL enabled.
```

i. Exit from the shell.

The TimesTen databases are running the correct release of TimesTen.

Congratulations! You successfully performed a manual upgrade for a non-replicated TimesTenClassic object. All replicas are ready and available. Pods are running the new TimesTen container image. TimesTen databases are upgraded and fully operational.

About Upgrading Direct Mode Applications

You cannot use the automated upgrade procedures to upgrade direct mode applications that are running in their own containers. The TimesTen Operator does propagate image changes from a TimesTenClassic object to the associated StatefulSet, but the changes do not initiate the automated upgrade process. You must manually terminate the applications that are running in the containers. In so doing, the StatefulSet spawns new containers to replace the original containers. These new containers run the new TimesTen image. For more information about direct mode applications, see About Using Direct Mode Applications.

About Failures During an Upgrade

If there are failures in any step of the upgrade process, a TimesTenClassic object enters the `ManualInterventionRequired` state. The remaining steps of the upgrade process are canceled. You must manually fix the TimesTenClassic object. See About the High Level State of TimesTenClassic Objects.

18

TimesTenClassic Object Type

This chapter gives an overview of the TimesTenClassic object type and describes its syntax

Topics:

- Overview of the TimesTenClassic Object Type
- Syntax for the TimesTenClassic Object Type

Overview of the TimesTenClassic Object Type

The TimesTen Kubernetes Operator (TimesTen Operator) installation defines the TimesTenClassic object type to the Kubernetes cluster. An object of type TimesTenClassic describes the metadata for deploying TimesTen Classic databases. You can create as many TimesTenClassic objects as you like.

The definition of the TimesTenClassic object type uses the same basic format that the formal Kubernetes documentation uses to define objects that are built-in to Kubernetes. The facilities available in any given Kubernetes cluster depend on what release of Kubernetes the cluster is using. For information on the Kubernetes API documentation, see:

`https://kubernetes.io/docs/reference/kubernetes-api/`

The Kubernetes API reference documentation refers to a number of built-in Kubernetes types used in the definition of the TimesTenClassic object type. A Kubernetes StatefulSet is of particular importance. The TimesTenClassic object type is basically a wrapper around a StatefulSet type. For more information, see:

`https://kubernetes.io/docs/reference/kubernetes-api/`

Syntax for the TimesTenClassic Object Type

The definition of the TimesTenClassic object type defines the set of attributes for deploying TimesTen Classic databases. The TimesTenClassic object type uses the following object definitions:

- TimesTenClassic
- TimesTenClassicSpec
- TimesTenClassicSpecSpec
- TimesTenClassicSpecSpecClientTLS
- TimesTenClassicSpecSpecCustomClientTLS
- TimesTenClassicSpecSpecPrometheus
- TimesTenClassicStatus

TimesTenClassic

An object of type TimesTenClassic describes the metadata for deploying TimesTen Classic databases.

The following table describes the syntax for the TimesTenClassic object type.

Table 18-1 TimesTenClassic syntax

Field	Type	Description
`apiVersion`	string	Versioned schema of this representation of an object. The TimesTen Kubernetes Operator supports `v5`, `v4`, and `v3` schema versions. The value must be `timesten.oracle.com/v5`, `timesten.oracle.com/v4` or `timesten.oracle.com/v3`. Use the `v5` schema version by specifying `timesten.oracle.com/v5`. The `v4` and `v3` schema versions are available to facilitate upwards compatibility from earlier releases of the TimesTen Operator. The `v3` schema version is deprecated. It is fully supported in this release, but will be removed in a future release. For more information about schema versions for TimesTenClassic objects, see About the TimesTenClassic CRD.
`kind`	string	Type of object. For example, TimesTenClassic.
`metadata`	`ObjectMeta`	Metadata about the object, such as its name. All of the object's metadata is passed from the object to the StatefulSet. For information about `ObjectMeta`, see: `https://kubernetes.io/docs/reference/kubernetes-api/`
`spec`	`TimesTenClassicSpec`	Desired configuration of TimesTen Pods and databases.
`status`	`TimesTenClassicStatus`	Current status of the Pods in this TimesTenClassic object as well as the status of various TimesTen components within those Pods. This data may be out of date by some window of time.

TimesTenClassicSpec

TimesTenClassicSpec appears in TimesTenClassic. The following table describes the syntax for TimesTenClassicSpec. The third column indicates the schema version in which the field was first introduced. For more information, see About the TimesTenClassic CRD.

Table 18-2 TimesTenClassicSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`ttspec`	`TimesTenClassicSpecSpec`	v3	Attributes specific to TimesTen.
`template`	`PodTemplateSpec`	v3	Describes the Pods provisioned for the TimesTenClassic object. In addition to Pods specified by `template`, there are the `tt` and `daemonlog` containers that are automatically included in each Pod. TimesTen runs in the `tt` container. If you configure and use Prometheus, the `exporter` container is also included. For information on `PodTemplateSpec`, see: `https://kubernetes.io/docs/reference/kubernetes-api/`
`volumeClaimTemplates`	`PersistentVolumeClaim`	v3	TimesTen automatically provisions PersistentVolumeClaims (PVCs) for `/tt` (and for `/ttlog`, if specified). If you have applications that are running in containers in the TimesTen Pods, and those applications require additional PVCs, specify them in this field. For information on `PersistentVolumeClaim`, see: `https://kubernetes.io/docs/reference/kubernetes-api/`

TimesTenClassicSpecSpec

TimesTenClassicSpecSpec appears in TimesTenClassicSpec.

The TimesTen Operator supports v5, v4, and v3 schema versions.

> **Note**
>
> The v3 schema version is deprecated. It is fully supported in this release, but will be removed in a future release.

For more information about schema versions, see About the TimesTenClassic CRD.

The following table details the fields for TimesTenClassicSpecSpec. Note the following:

- The fields are in alphabetical order.
- The third column indicates the earliest schema version the field was supported in.
- There are some fields of type quantity. The specified value is of the same format as Kubernetes resource limits. For example, 200Gi, 200G, 1000Mi, 1000M, and so on.

- There are fields that are reserved for internal use and are not documented in this table. The names of these fields typically begin with `zz`. For example, `zzTestInfo` is reserved for internal use.

Table 18-3 TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`additionalMemoryRequest`	quantity	`v3`	The amount of `memory` to request in addition to whatever is required for the TimesTen database. This memory is used for the TimesTen daemon, subdaemons, agents, and the Client/Server server. This value is added to `databaseMemorySize` that was either specified by you or calculated. The sum is the `memory` request to Kubernetes. The default is `2Gi`.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`agentAsyncTimeout`	integer	v3	At times the TimesTen Operator needs to perform operations on a TimesTen instance or database. When the TimesTen Operator needs to perform such operations, it asks the TimesTen Agent running in the `tt` container of the appropriate Pod to perform the operation. The Agent issues TimesTen commands and utilities and, using the TimesTen `ttIsql` utility, runs SQL operations on the appropriate instance or database. The Agent runs the operation either synchronously (while the TimesTen Operator waits) or asynchronously (while the TimesTen Operator is not waiting and can perform other operations for other TimesTen objects). The only operation that is performed asynchronously is duplicate, where a TimesTen Classic database is copied from the active Pod to the standby Pod. This is done as part of the initial rollout of an active standby pair, and at various times during its lifecycle. These duplicate operations can take a long time, and the amount of time increases as the size of the database increases. If an asynchronous operation does not complete within `agentAsyncTimeout` seconds, the TimesTen Operator decides that it has failed and acts accordingly. If your database is large, you may need to increase the default value for `agentAsyncTimeout`. The default is `600` and is expressed in seconds.
`agentGetTimeout`	integer	v3	Time in seconds that the TimesTen Operator waits for an https `GET` request to be processed by the TimesTen agent. This includes the TCP and the TLS times as well as the time it takes for the TimesTen agent to implement the `GET` request. The default is `60`. A value of `0` indicates that there is no timeout. If the timeout is exceeded, the TimesTen Operator considers the agent to be down.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`agentPostTimeout`	integer	v3	Time in seconds that the TimesTen Operator waits for an https `POST` request to be processed by the TimesTen agent. This includes the TCP and the TLS times as well as the time it takes for the TimesTen agent to implement the `POST` request. The `POST` requests may take a long time and the time may be proportional to the size of the database. (An example is a `POST` request to duplicate a database from the active to the standby.) The default is `600`. A value of `0` indicates that there is no timeout. If the timeout is exceeded, the TimesTen Operator considers the `POST` request to have failed.
`agentTcpTimeout`	integer	v3	Time in seconds that the TimesTen Operator waits for a TCP handshake when communicating with the TimesTen agent. The default is `10`. A value of `0` indicates that there is no timeout. If the timeout is exceeded, the TimesTen Operator considers the agent to be down.
`agentTlsTimeout`	integer	v3	Time in seconds that the TimesTen Operator waits for a TLS (https) credential exchange when communicating with the TimesTen agent. The default is `10`. A value of `0` indicates that there is no timeout. If the timeout is exceeded, the TimesTen Operator considers the agent to be down.
`automaticMemoryRequests`	boolean	v3	Determines if the TimesTen Operator attempts to set appropriate memory limits and requests for TimesTen Pods. Valid values: • `true` (default): The TimesTen Operator attempts to set memory limits and requests. • `false`: The TimesTen Operator does not set memory limits and requests.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`bothDownBehavior`	string	v3	If the TimesTenClassic object enters the `BothDown` state, the TimesTen Operator examines the `bothDownBehavior` setting to determine what to do. Acceptable values are `Best` (default) or `Manual`. See BothDown.
`cacheCleanup`	boolean	v3	Determines if the metadata in the Oracle Database should be cleaned up when this TimesTenClassic object is deleted. Use for TimesTen Cache only. Valid values: • `true` (or not specified): The metadata is cleaned up. • `false`: The metadata is not cleaned up. See Dropping Oracle Database Objects Used by Cache Groups with Autorefresh in the *Oracle TimesTen In-Memory Database Cache Guide*.
`clientTLS`	`TimesTenClassicSpecSpec ClientTLS`	v4	If specified, the TimesTen Operator can automatically create self-signed certificates and configure TimesTen to use those certificates for client/server encryption. The fields for the `clientTLS` object are defined in TimesTenClassicSpecSpecClientTLS. For more information about how the TimesTen Operator automatically generates certificates and configures client/server TLS connections, see Automatically Configure Client/Server TLS.
`createASReadinessProbe`	boolean	v3	Determines if the TimesTen Operator creates a readiness probe for a replicated TimesTenClassic object. Valid values: • `true` (default): The TimesTen Operator creates a readiness probe. • `false`: The TimesTen Operator does not create a readiness probe. See About Readiness Probes for TimesTen Containers.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`customClientTLS`	`TimesTenClassicSpecSpec CustomClientTLS`	v5	If specified, indicates the use of bring your own certificates. The TimesTen Operator automatically configures TimesTen to use those certificates for client/server encryption. The fields for the `customClientTLS` object are defined in TimesTenClassicSpecSpecCustomClientTLS.
`daemonLogCPURequest`	quantity	v3	The amount of CPU requested for the `daemonlog` container. The default is `200m` (one-fifth of a CPU).
`daemonLogMemoryRequest`	quantity	v3	The amount of memory requested for the `daemonlog` container. The default is `200Mi`.
`daemonLogSidecar`	boolean	v3	Determines if a daemon log container is created in each TimesTen Pod. This container writes the TimesTen daemon logs (from `ttmesg.log`) to `stdout`. This causes Kubernetes to record these logs. Valid values: • `true` (or not specified): A daemon log container is created. • `false`: A daemon log container is not created.
`databaseCPURequest`	quantity	v3	Specify this value to tell the TimesTen Operator how much CPU your `tt` containers require. This includes CPU used by the TimesTen daemon, subdaemons, replication agents, cache agents, and the Client/Server server. There is no default.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`databaseMemorySize`	quantity	v3	You can specify this value to tell the TimesTen Operator how much shared memory your database requires. If you specify a value, that value will be used. If you do not specify a value, the TimesTen Operator attempts to determine the required size from the provided `db.ini` file. If the TimesTen Operator cannot determine the database size, the value `580911104` is used. This is the size required for a default database with a `PermSize` of 200Mbyte, rounded up to 2Mi. This may be useful for experimentation, but is likely insufficient for production purposes. TimesTen recommends that you provide a `db.ini` file to the TimesTen Operator by using a Configmap or Secret, and that you not specify `databaseMemorySize`. **Note** If you provide a `db.ini` file by using an init container, you must specify `databaseMemorySize`.
`dbConfigMap`	array of strings	v3	Name of one or more ConfigMaps to be included in a projected volume. This projected volume is mounted as `/ttconfig` in the TimesTen containers. If you do not specify `dbConfigMap` or `dbSecret`, you must place the metadata files into the `/ttconfig` directory by using other means. See Populate the /ttconfig Directory.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`dbSecret`	array of strings	v3	Name of one or more Secrets to be included in a projected volume. This projected volume is mounted as `/ttconfig` in the TimesTen containers. If you do not specify `dbSecret` or `dbConfigMap`, you must place the metadata files into the `/ttconfig` directory by using other means. See Populate the /ttconfig Directory.
`deleteDbOnNotReadyNode`	integer	v3	When specified, this datum directs the TimesTen Operator to detect situations where a Node is not ready (or unknown) for a specific period of time. When detected, the TimesTen Operator takes appropriate action to remedy the situation. Specifically, the TimesTen Operator checks to see if the Node's not ready condition has existed for more than `deleteDbOnNotReadyNode` seconds. If so, the TimesTen Operator deletes the Pod and the PVCs associated with the Pod. This causes Kubernetes to create a new Pod and new PVCs on a surviving Node. Once the Pod is scheduled and started by Kubernetes, the TimesTen Operator configures it as usual. The value is expressed in seconds and must be greater than `pollingInterval`. By default, this datum is not specified in your TimesTenClassic object definition. You must specify it. Note: Use caution when specifying this datum. Specifying this datum could result in the TimesTen Operator deleting PVCs. Deleting PVCs discards the on-disk copy of TimesTen databases. For more information, see How the TimesTen Kubernetes Operator Handles Node Failure.
`exporterCPURequest`	quantity	v3	The amount of CPU requested for the `exporter` container (if provisioned). The default is `200m` (one-fifth of a CPU).
`exporterMemoryRequest`	quantity	v3	The amount of memory requested for the `exporter` container (if provisioned). The default is `200Mi`.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`image`	string	v3	Name of the TimesTen image that is executed in the created containers. There is no default. You must specify the name of the `image`.
`imagePullPolicy`	string	v3	Determines if and when Kubernetes pulls the TimesTen image from the image repository. Valid values: • `Always` • `IfNotPresent` (default) • `Never` Note: Values are case sensitive.
`imagePullSecret`	string	v3	Image pull secret that is used to authenticate and give permission to Kubernetes to fetch the specified TimesTen image from its image repository. There is no default. You must specify the name of the image pull secret.
`imageUpgradeStrategy`	string	v3	Determines if the TimesTen Operator performs automated upgrades. Valid values: • `Auto` (or not specified): The TimesTen Operator performs automated upgrades. • `Manual`: The TimesTen Operator does not perform an automated upgrade. Values are case sensitive. See Perform Upgrades.
`logStorageClassName`	string	v3	Name of the storage class that is used to request persistent volumes for the TimesTen database transaction log files. This field is optional.
`logStorageSelector`	`metav1.LabelSelector`	v3	When choosing to use a persistent volume to store the TimesTen transaction logs, the primary determinant of what volumes to use is the `logStorageClassName` field that you specify. You can optionally specify a label selector by using the `logStorageSelector` field. This label selector further filters the set of volumes. See: `https://kubernetes.io/docs/concepts/storage/persistent-volumes/#selector`

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`logStorageSize`	string	v3	Amount of storage to be provisioned for the TimesTen transaction logs. For information on determining the amount of storage needed for the transaction log files, see Storage Provisioning for TimesTen in the *Oracle TimesTen In-Memory Database Operations Guide* The default is `50Gi`. This default value may be suitable when you are experimenting with the product or using it for demonstration purposes. However, in a production environment, consider choosing a value greater than `50Gi`. The examples in this book assume a production environment and use a value of `250Gi`.
`memoryWarningPercent`	integer	v3	At runtime, if a container's memory usage is more than its percentage of its limit (both as reported by cgroups), the TimesTen Operator generates Events to inform you of this occurrence. The memory usage refers to the container's `memory` allocation. The default is `90`.
`pollingInterval`	integer	v3	Determines how often (expressed in seconds) that the TimesTen Operator checks the status of the TimesTenClassic object. For example, if you set this value to `10`, the TimesTen Operator checks the status of the TimesTenClassic object every ten seconds. This value interacts with `unreachableTimeout`. The `pollingInterval` value should be smaller than the `unreachableTimeout` value. The value must be a positive integer (greater than `0`). The default is 5.
`prometheus`	`TimesTenClassicSpecSpec Prometheus`	v3	Determines if the TimesTen Exporter is deployed. If specified, the Exporter is deployed. The fields for the `prometheus` object are defined in TimesTenClassicSpecSpecPrometheus .

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`readOnlyRootFilesystem`	boolean	v3	Determines if the TimesTen Operator causes the container image to be mounted read-only in TimesTen containers. In addition, determines if the TimesTen Operator provisions an empty directory and mounts it on top of the `/tmp` directory in all TimesTen containers in all TimesTen Pods. This includes the `tt`, `daemonlog`, and `exporter` containers in each Pod. Valid values: • `true` (default): The TimesTen Operator provisions an empty directory and mounts it on top of the `/tmp` directory. In addition, the TimesTen Operator creates these containers with container images mounted as read-only. • `false`: The TimesTen Operator does not provision an empty directory and does not create containers with container images mounted as read-only. If you provide your own containers, the TimesTen Operator does not automatically mount your container images as read-only. If you upgrade a `v1` TimesTenClassic object and if the Pods associated with that TimesTenClassic object are replaced, the replacements do not have `readOnlyRootFilesystem` set.
`reexamine`	string	v3	When a TimesTenClassic object is in the `ManualInterventionRequired` state, the TimesTen Operator examines the `reexamine` value every `pollingInterval` seconds. If the value has changed since the last iteration for this object, the TimesTen Operator examines the state of the TimesTen containers for this object. See About the ManualInterventionRequired State for Replicated Objects and About Bringing Up One Database.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description

`repCreateStatement`	string	v3	The `repReturnServiceAttribute` and the `repStoreAttribute` fields provide some control over the `CREATE ACTIVE STANDBY` statement that you use to configure your active standby pair replication scheme. However, these fields do not provide a mechanism to set all the replication options.
			The `repCreateStatement` field provides more control over the active standby pair replication configuration. If you choose to define a replication scheme, you must choose either the `repCreateStatement` approach or the `repReturnServiceAttribute` and the `repStoreAttribute` approach. You cannot use both approaches simultaneously in a single TimesTenClassic object definition. For example, you cannot use the `repCreateStatement` and the `repReturnServiceAttribute` fields in a single TimesTenClassic object definition. However, you can use the `repReturnServiceAttribute` and the `repStoreAttribute` fields in a single TimesTenClassic object definition.
			Example of using `repCreateStatement`:
			`apiVersion: timesten.oracle.com/`
			`v4`
			`kind: TimesTenClassic`
			`metadata:`
			` name: sample`
			`spec:`
			`  ttspec:`
			` repCreateStatement: |`
			`      create active standby pair`
			`        "{{tt-name}}" on "{{tt-`
			`node-0}}",`
			`        "{{tt-name}}" on "{{tt-`
			`node-1}}"`
			`      RETURN TWOSAFE`
			`      store "{{tt-name}}" on`
			`"{{tt-node-0}}"`
			`        PORT {{tt-rep-port}}`
			`FAILTHRESHOLD 10 TIMEOUT 5`
			`        DISABLE RETURN ALL 10`
			`      store "{{tt-name}}" on`

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description

			`"{{tt-node-1}}"`
			`        PORT {{tt-rep-port}}`
			`FAILTHRESHOLD 10 TIMEOUT 5`
			`        DISABLE RETURN ALL 10`
			
			The TimesTen Operator does the substitutions for you.
			• `{{tt-name}}`: The name of the TimesTenClassic object. (For example, `sample`.)
			• `{{tt-node-0}}`: The fully qualified DNS name of the `-0` Pod for the TimesTenClassic object. (For example, `sample-0.sample.mynamespace.svc.cluster.local`.)
			• `{{tt-node-1}}`: The fully qualified DNS name of the `-1` Pod for the TimesTenClassic object. (For example, `sample-1.sample.mynamespace.svc.cluster.local`.)
			• `{{tt-rep-port}}`: The TCP port either chosen by the TimesTen Operator or specified in the `repPort` field.
			When you use the `repCreateStatement` field, you have nearly complete control over the replication configuration. The TimesTen Operator executes the statement you define (after substituting a number of values into it). Since the TimesTen Operator is using the `CREATE` statement that you define, ensure that the statement you specify is correct and appropriate. If the creation of your active standby pair replication scheme fails, your TimesTenClassic object transitions from the `Initializing` state to the `Failed` state. You must then delete the TimesTenClassic object to clean up the resources it holds. See About the High Level State of TimesTenClassic Objects.
			The configuration has the following restrictions:
			• Must be an active standby pair.
			• Must not be configured with subscribers.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
			See CREATE ACTIVE STANDBY PAIR in the *Oracle TimesTen In-Memory Database SQL Reference* and Defining an Active Standby Pair Replication Scheme in the *Oracle TimesTen In-Memory Database Replication Guide*.
`replicas`	integer	v3	Valid for non-replicated database configurations. Number of TimesTen Pods to provision. You can only specify `replicas` if the value of `replicationTopology` is `none`. The minimum value is `1`. The maximum value is `3`. The default is `1`. You cannot change the value of `replicas` once the TimesTenClassic object is created. For more information, see Create TimesTen Classic Databases.
`replicationCipherSuite`	string	v3	Determines the encryption algorithm to be used by TimesTen replication. If specified, replication traffic is encrypted. You can specify one or more cipher suites. Specify the desired cipher suites, comma-separated and in order of preference. The supported cipher suites are as follows: • `SSL_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256` • `SSL_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384` • `SSL_RSA_WITH_AES_128_CBC_SHA256` See Configuration for TLS for Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`replicationSSLMandatory`	integer	v3	Determines if SSL encryption is mandatory for replication. Valid values: • `0` (or not specified): SSL encryption is not mandatory for replication. • 1: SSL encryption is mandatory for replication. This field is only examined if `replicationCipherSuite` is specified. See About Using Certificates with Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.
`replicationTopology`	string	v3	Determines if replication should be configured. Valid values: • `activeStandbyPair` (default): The TimesTen Operator configures an active standby pair replication scheme. • `none`: The TimesTen Operator does not configure replication. Instead, it configures a non-replicated configuration and uses the `replicas` field to determine how many TimesTen Pods to create. For more information, see Create TimesTen Classic Databases.
`repPort`	integer	v3	TCP port used for replication. The default is 4444.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`repReturnServiceAttribute`	string	v3	You can use the `repReturnServiceAttribute` field to specify the *`ReturnServiceAttribute`* clause. This clause is part of the syntax for the `CREATE ACTIVE STANDBY PAIR` statement. The information you specify is included in your active standby pair's `CREATE ACTIVE STANDBY PAIR` statement by the TimesTen Operator. Do not specify the `repReturnServiceAttribute` field if you have specified the `repCreateStatement` field. If you do not specify the `repReturnServiceAttribute` field (or the `repCreateStatement` field), the default is `NO RETURN`. See CREATE ACTIVE STANDBY PAIR in the *Oracle TimesTen In-Memory Database SQL Reference* and Defining an Active Standby Pair Replication Scheme in the *Oracle TimesTen In-Memory Database Replication Guide* for information on the `CREATE ACTIVE STANDBY PAIR` statement and the *`ReturnServiceAttribute`* clause.
`repStateTimeout`	integer	v3	Time in seconds a replicated database remains in the `recovering` replication state as reported by the TimesTen `ttRepStateGet` built-in procedure. The `recovering` replication state indicates the database is in the process of synchronizing updates with the active database after a failure. See ttRepStateGet in the *Oracle TimesTen In-Memory Database Reference*. The default is `30`.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`repStoreAttribute`	string	v3	You can use the `repStoreAttribute` field to specify the *`StoreAttribute`* clause. This clause is part of the `CREATE ACTIVE STANDBY PAIR` statement. The information you specify is included in your active standby pair's `CREATE ACTIVE STANDBY PAIR` statement by the TimesTen Operator. Do not specify the `repStoreAttribute` field if you have specified the `repCreateStatement` field. If you do not specify the `repStoreAttribute` field (or the `repCreateStatement` field), the default is: `PORT` *`repPort`* `FAILTHRESHOLD 0`. If you specify the `repStoreAttribute`, you must specify the port. This port is used by replication. The port must match the port provided in the `repPort` field (or must match the default value if `repPort` is not specified). If the ports do not match, the TimesTenClassic object enters the `Failed` state. See CREATE ACTIVE STANDBY PAIR in the *Oracle TimesTen In-Memory Database SQL Reference* and Defining an Active Standby Pair Replication Scheme in the *Oracle TimesTen In-Memory Database Replication Guide* for information on the `CREATE ACTIVE STANDBY PAIR` statement and the *`StoreAttribute`* clause.
`resetUpgradeState`	string	v3	The `resetUpgradeState` field allows an online upgrade to be canceled.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`rollingUpdatePartition`	integer	v3	Specific to upgrading a non-replicated configuration. Kubernetes upgrades Pods with an ordinal value that is greater than or equal to the `rollingUpdatePartition` value. Pods with an ordinal value that is less than `rollingUpdatePartition` are not upgraded. For example, if you have three non-replicated Pods (`replicas` = 3 and Pods are `samplerep-0`, `samplerep-1`, and `samplerep-2`) and you set `rollingUpdatePartition` to 1, the `samplerep_1` and `samplerep-2` Pods are upgraded, but the `samplerep-0` Pod is not. The default is `0`. For more information, see Perform Upgrades in this book and Partitioned rolling updates in the Kubernetes documentation.
`stopManaging`	string	v3	If you change the value of `stopManaging` for the TimesTenClassic object, the TimesTen Operator places the object in the `ManualInterventionRequired` state. See About the ManualInterventionRequired State for Replicated Objects and About Bringing Up One Database.
`storageClassName`	string	v3	Name of the storage class that is used to request persistent volumes for the TimesTen database. There is no default. You must specify the name of the storage class.
`storageSelector`	`metav1.LabelSelector`	v3	When choosing to use a persistent volume to store a TimesTen database, the primary determinant of what volumes to use is the `StorageClassName` that you specify. You can optionally specify a label selector by using the `storageSelector` field. This label selector further filters the set of volumes. See: `https://kubernetes.io/docs/concepts/storage/persistent-volumes/#selector`

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`storageSize`	string	v3	Amount of storage to be provisioned for TimesTen and the database. For information on determining the amount of storage needed for TimesTen, see Storage Provisioning for TimesTen in the *Oracle TimesTen In-Memory Database Operations Guide* . The default is `50Gi`. This default value may be suitable when you are experimenting with the product or using it for demonstration purposes. However, in a production environment, consider choosing a value greater than `50Gi`. The examples in this book assume a production environment and use a value of `250Gi`.
`storePassword`	string	v4	The TimesTen Operator stores its security certificates in Java Keystores. In order to create and use Java Keystores, they must be secured with a known password (`storePassword`). The password must be known by both the TimesTen Operator who creates and reads the keystore and the TimesTen Agent who also reads it. The default value is a hard-coded string that is not documented. Although not recommended, you can use the `storePassword` datum to set the password to a different value than the default and control the password setting. Once set, you cannot change `storePassword`. If it is changed, the TimesTen Operator generates a warning in the form of a Kubernetes Event and ignores the changed value.
`terminationGracePeriod`	integer	v3	Amount of time (in seconds) that Kubernetes waits for a Pod to gracefully shut down before being forcefully terminated. The default varies depending on your configuration: • Replicated (Active Standby Pair): Default is `10` seconds. • Non-replicated: Default is `300` seconds.

Table 18-3 (Cont.) TimesTenClassicSpecSpec syntax

Field	Type	Earliest Schema Version Supported In	Description
`unreachableTimeout`	integer	v3	Number of seconds that a TimesTen instance or TimesTen database is unavailable before the TimesTen Operator takes action to fail over or otherwise recover from the issue. This value interacts with `pollingInterval`. The `pollingInterval` value should be smaller than the `unreachableTimeout` value. The value must be a positive integer (greater than `0`). The default is `30`.
`upgradeDownPodTimeout`	integer	v3	Maximum amount of seconds that the TimesTenClassic object remains in the `WaitingForActive` state. After this period of time, if the TimesTenClassic object is still in the `WaitingForActive` state, it transitions to the `ManualInterventionRequired` state. The default is `0` (which means there is no timeout. The TimesTenClassic object waits forever, if required). For information on the `WaitingForActive` and the `ManualInterventionRequired` states, see About the High Level State of TimesTenClassic Objects.

TimesTenClassicSpecSpecClientTLS

TimesTenClassicSpecSpecClientTLS appears in TimesTenClassicSpecSpec.

The following table describes the syntax for TimesTenClassicSpecSpecClientTLS.

Table 18-4 TimeTenClassicSpecSpecClientTLS

Field	Type	Earliest Schema Version Supported In	Description
`auto`	boolean	`v4`	Determines if the TimesTen Operator automatically creates self-signed certificates and configures TimesTen to use those certificates for client/server encryption. Valid values are the following: • `true`: The TimesTen Operator automatically creates and configures self-signed certificates for client/server encryption. • `false` (default): The TimesTen does not automatically create and configure self-signed certificates for client/server encryption. If you do not specify the `auto` datum, and any other field is specified in the `.spec.ttspec.clientTLS` clause, the default value for the `auto` datum is `false`.

Table 18-4 (Cont.) TimeTenClassicSpecSpecClientTLS

Field	Type	Earliest Schema Version Supported In	Description
`ciphersuites`	string	v4	Defines the cipher suite(s) used for client/server communication. You can specify one or more cipher suites. Specify the desired cipher suites, comma-separated, and in order of preference. The supported cipher suites are as follows: • `TLS_AES_128_CCM_SHA256` • `TLS_AES_128_GCM_SHA256` • `TLS_AES_256_GCM_SHA384` • `TLS_CHACHA20_POLY1305_SHA256` (non-FIPS only) • `TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256` • `TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384` The TimesTen Operator first checks to see if there is a `ciphersuites` entry in the `db.ini` file. • If there is an entry, the TimesTen Operator uses it. • If there is no entry, the TimesTen Operator uses the value specified in this datum. • If `.spec.ttspec.clientTLS.auto` is `true`, and there is no value specified in either the `db.ini` file or in this datum, the TimesTen Operator sets the value to `TLS_AES_256_GCM_SHA384`. The TimesTen Operator adds the `ciphersuites` value to the TimesTen Server's `sys.odbc.ini` file. See Configuration for TLS for Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.
`eccurve`	string	v4	Defines the size of the elliptical curve. The supported values are as follows: • `p256` • `p384` (default) • `p521` See the `-eccurve` option of the TimesTen ttCreateCerts utility in the *Oracle TimesTen In-Memory Database Reference*.

Table 18-4 (Cont.) TimeTenClassicSpecSpecClientTLS

Field	Type	Earliest Schema Version Supported In	Description
`encryption`	string	v4	Defines the encryption setting for client/ server access. The supported values are as follows: • `accepted` • `rejected` • `requested` • `required` The TimesTen Operator first checks to see if there is an `encryption` entry in the `db.ini` file. • If there is an entry, the TimesTen Operator uses it. • If there is no entry, the TimesTen Operator uses the value specified in this datum. • If `.spec.ttspec.clientTLS.auto` is `true`, and there is no value specified in either the `db.ini` file or in this datum, the TimesTen Operator sets the value to `accepted`. The TimesTen Operator adds the `encryption` value to the TimesTen Server's `sys.odbc.ini` file. See Configuration for TLS for Client/ Server in the *Oracle TimesTen In-Memory Database Security Guide*.
`signAlg`	string	v4	Defines the elliptical curve signing algorithm. The supported values are as follows: • `ecdsasha256` • `ecdsasha384` (default) • `ecdsasha512` See the `-sign_alg` option of the TimesTen ttCreateCerts utility in the *Oracle TimesTen In-Memory Database Reference*.
`validity`	integer	v4	Defines the number of days the created certificate is valid. The minimum is `30` and the maximum is `9999`. The default is `3650`. See the `-validity` option of the TimesTen ttCreateCerts utility in the *Oracle TimesTen In-Memory Database Reference*.

TimesTenClassicSpecSpecCustomClientTLS

TimesTenClassicSpecSpecCustomClientTLS appears in TimesTenClassicSpecSpec.

The following table describes the syntax for TimesTenClassicSpecSpecCustomClientTLS.

Table 18-5 TimeTenClassicSpecSpecCustomClientTLS

Field	Type	Earliest Schema Version Supported In	Description
`ciphersuites`	string	v5	Defines the cipher suite(s) used for client/server communication. You can specify one or more cipher suites. Specify the desired cipher suites, comma-separated, and in order of preference. The supported cipher suites for ECC keys are as follows: • `TLS_AES_128_CCM_SHA256` • `TLS_AES_128_GCM_SHA256` • `TLS_AES_256_GCM_SHA384` • `TLS_CHACHA20_POLY1305_SHA256` (non-FIPS only) • `TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256` • `TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384` The supported cipher suites for RSA keys are as follows: • `TLS_AES_128_CCM_SHA256` • `TLS_AES_128_GCM_SHA256` • `TLS_AES_256_GCM_SHA384` • `TLS_CHACHA20_POLY1305_SHA256` (non-FIPS only) • `TLS_DHE_RSA_WITH_AES_128_GCM_SHA256` • `TLS_DHE_RSA_WITH_AES_256_GCM_SHA384` • `TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256` • `TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384` The TimesTen Operator first checks to see if there is a `ciphersuites` entry in the `db.ini` file. • If there is an entry, the TimesTen Operator uses it. • If there is no entry, the TimesTen Operator uses the value specified in this datum. • If there is no value specified in either the `db.ini` file or in this datum, the TimesTen Operator sets the value to `TLS_AES_256_GCM_SHA384`. The TimesTen Operator adds the `ciphersuites` value to the TimesTen Server's `sys.odbc.ini` file.

Table 18-5 (Cont.) TimeTenClassicSpecSpecCustomClientTLS

Field	Type	Earliest Schema Version Supported In	Description
			See Configuration for TLS for Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.
`encryption`	string	v5	Defines the encryption setting for client/server access. The supported values are as follows: • `accepted` • `rejected` • `requested` • `required` The TimesTen Operator first checks to see if there is an `encryption` entry in the `db.ini` file. • If there is an entry, the TimesTen Operator uses it. • If there is no entry, the TimesTen Operator uses the value specified in this datum. • If there is no value specified in either the `db.ini` file or in this datum, the TimesTen Operator sets the value to `accepted`. The TimesTen Operator adds the `encryption` value to the TimesTen Server's `sys.odbc.ini` file. See Configuration for TLS for Client/Server in the *Oracle TimesTen In-Memory Database Security Guide*.
`gracePeriod`	integer	v5	Defines the amount of time (expressed in hours) that the Operator waits to finish the rotation of certificates. When the grace period is reached, the TimesTen Operator completes the rotation by automatically deleting old certificates and continuing with the most recent. Note: • Minimum value is `0`, indicating there is no grace period. • Maximum value is 96. • The default value is 24.
`serverCert`	string	v5	Defines a secret containing a PKCS#12 (PFX) file with the full chain of the server certificate.

TimesTenClassicSpecSpecPrometheus

TimesTenClassicSpecSpecPrometheus appears in TimesTenClassicSpecSpec.

The following table describes the syntax for TimesTenClassicSpecSpecPrometheus.

Table 18-6 TimesTenClassicSpecSpecPrometheus syntax

Field	Type	Earliest Schema Version Supported In	Description
`certSecret`	string	v3	When using https to serve TimesTen metrics, a Kubernetes Secret is required. If you create your own Kubernetes Secret, use the `certSecret` field to specify the name of this Secret. This Secret contains an Oracle Wallet that holds the necessary certificates used by the TimesTen exporter for serving TimesTen metrics by https. See Create Your Own Oracle Wallet, Certificates, and Secrets for Exposing TimesTen Metrics. If you want the TimesTen Operator to automatically create an Oracle Wallet, certificates, and Kubernetes Secrets that are required for https, do not specify the `certSecret` field. We recommend this approach. See About Transport Layer Security (mutual TLS) Certificates for TimesTen Metrics.
`createPodMonitors`	boolean	v3	Determines if the TimesTen Kubernetes Operator creates PodMonitors. Valid values: • `true` (or not specified): The TimesTen Operator creates PodMonitors. • `false`: The TimesTen Operator does not create PodMonitors. See Expose TimesTen Metrics with the TimesTen Kubernetes Operator.

Table 18-6 (Cont.) TimesTenClassicSpecSpecPrometheus syntax

Field	Type	Earliest Schema Version Supported In	Description
`insecure`	boolean	v3	Determines if the TimesTen exporter is started with no authentication or with Transport Layer Security (mutual TLS). Valid values: • `true`: The TimesTen exporter is started with no authentication and serves data by http. • `false` (or not specified): The TimesTen exporter is started with mutual TLS and serves data by https. For more information, see About Using http or https for TimesTen Metrics. For information about the TimesTen exporter, see About the TimesTen Exporter in the *Oracle TimesTen In-Memory Database Monitoring and Troubleshooting Guide*.
`limitRate`	integer	v3	Determines the limit of GET requests per minute that the TimesTen exporter accepts. The value can be any integer value from `1` to `15`. The default is `10`.
`port`	integer	v3	Port on which the TimesTen exporter listens. The default is `8888`.

Table 18-6 (Cont.) TimesTenClassicSpecSpecPrometheus syntax

Field	Type	Earliest Schema Version Supported In	Description
`publish`	boolean	v3	Determines if the TimesTen Operator provisions a TimesTen exporter container. Valid values: • `true` (or not specified): The TimesTen Operator provisions a TimesTen exporter container. • `false`: The TimesTen Operator does not provision a TimesTen exporter container. If you do not specify the `publish` field, and any other field is specified in the `.spec.ttspec.prometheus` clause, the default value for the `publish` field is `true`. If you do not specify the `.spec.ttspec.prometheus` clause and the TimesTen release is 22.1 or greater, the default value for the `publish` field is dependent on the value of the `EXPOSE_METRICS` TimesTen Operator environment variable: • If `EXPOSE_METRICS` is `"1"` (or not specified), the TimesTen Operator treats the `publish` field as `true`. • If `EXPOSE_METRICS` is `"0"`, the TimesTen Operator treats the `publish` field as `false`. For more information, see Expose TimesTen Metrics with the TimesTen Kubernetes Operator and TimesTen Kubernetes Operator Environment Variables.

TimesTenClassicStatus

TimesTenClassicStatus appears in TimesTenClassic. The Operator stores various persistent information in TimesTenClassicStatus.

The output of the `kubectl get` and `kubectl describe` commands display information in TimesTenClassicStatus. This information includes the following:

- `awtBehindMb`: a field that is present only if AWT (Asynchronous WriteThrough) is in use. The field represents how many megabytes of log is present in TimesTen that has not yet been pushed to Oracle Database. For more information on AWT cache group, see Overview of Cache Groups in the *Oracle TimesTen In-Memory Database Cache Guide*.

- High Level state of the Active Standby Pair: a string that describes the High Level state of the active standby pair.
- Detailed state of TimesTen in each Pod, which includes the following:
  - Is the TimesTen agent running?
  - Is the TimesTen main daemon running?
  - Is the TimesTen replication agent running?
  - Is the TimesTen cache agent running?
  - Is there a database in the instance?
  - Is the database loaded?
  - Is the database updatable or read only?
  - Is there a replication scheme in the database?
  - What is the replication state of this database?
  - What does this database think the replication state of its peer is?
  - What is the role for TimesTen in this Pod (active or standby)?
  - What is the High Level state of the Pod?

Note

Unknown values can occur if, for example, the agent is not running or a Pod is unavailable.

19 Helm Charts for the TimesTen Kubernetes Operator

There are four Helm charts that allow you to deploy the TimesTen CRD, the TimesTen Operator, and TimesTenClassic objects. Each chart contains variables and default values that are specific to the chart. The names of the charts are as follows:

- `ttcrd`: Deploys the TimesTen CRD in your Kubernetes cluster. You cannot change the values of the variables in this chart.
- `ttoperator`: Deploys the TimesTen Operator in a namespace in your Kubernetes cluster. The TimesTen Operator runs at namespace-scope and services TimesTenClassic objects in this namespace. You have the option of defining your own values for variables in this chart.
- `ttclusteroperator`: Deploys the TimesTen Operator in the `timesten-operator` namespace in your Kubernetes cluster. The TimesTen Operator runs at cluster-scope and services TimesTenClassic objects in all namespaces in the cluster. The `timesten-operator` namespace is created by the TimesTen Operator and cannot be modified. You have the option of defining your own values for variables in this chart.
- `ttclassic`: Deploys a TimesTenClassic object. The TimesTen Operator creates TimesTen Classic databases based on the object's definition. You have the option of defining your own values for variables in this chart.

The following sections describe the values and defaults values for the `ttoperator`, `ttclusteroperator`, and `ttclassic` charts:

- The ttoperator Chart
- The ttclusteroperator Chart
- The ttclassic Chart

For detailed information about using Helm, see Use Helm in Your TimesTen Kubernetes Operator Environment.

The ttoperator Chart

The `ttoperator` chart deploys the TimesTen Operator in a namespace in your Kubernetes cluster. The TimesTen Operator runs at namespace-scope and services TimesTenClassic objects in this namespace.

The following table describes the variables and default values for the `ttoperator` chart. Indentation and case sensitivity must be correct for each variable. There may be some variables that exist in the product, but are not documented.

Table 19-1   Variables for the ttoperator Chart

Variable	Description	Description
`affinity`	Variable that defines Kubernetes `nodeAffinity`, `podAffinity`, and `podAntiAffinity` parameters. There is no default. However, if you are using a multi-architecture cluster that consists of `amd64` and `arm64` nodes, you must instruct Kubernetes to deploy the TimesTen Operator on a specific architecture.	`affinity:` `nodeAffinity:` `requiredDuringSchedulingIgnoredDuringExecution:` `nodeSelectorTerms:` `- matchExpressions:` `- key: topology.kubernetes.io/zone` `operator: In` `values:` `- antarctica-east1` `- antarctica-west1` Here is an example that shows how to instruct Kubernetes to deploy the TimesTen Operator and the objects it manages on `arm64` nodes: `affinity:` `nodeAffinity:` `requiredDuringSchedulingIgnoredDuringExecution:` `nodeSelectorTerms:` `- matchExpressions:` `- key: topology.kubernetes.io/zone` `operator: In` `values: ["arm64"]` Valid values for `values` are: • `"amd64"`: Use this for TimesTen Operators that you want to run on `amd64` nodes. • `"arm64"`: Use this for TimesTen Operators that you want to run on `arm64` nodes. Here is a complete affinity section with node affinity and pod affinity sections: `affinity: {}` `nodeAffinity:` `requiredDuringSchedulingIgnoredDuringExecution:` `nodeSelectorTerms:` `- matchExpressions:`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description

		`          - key: "kubernetes.io/arch"`
		`            operator: In`
		`            values: ["amd64"]`
		
		`  nodeAffinity:`
		
		`requiredDuringSchedulingIgnoredDuringExecution:`
		`      nodeSelectorTerms:`
		`      - matchExpressions:`
		`        - key: topology.kubernetes.io/zone`
		`          operator: In`
		`          values:`
		`          - antarctica-east1`
		`          - antarctica-west1`
		
		`preferredDuringSchedulingIgnoredDuringExecution:`
		`    - weight: 1`
		`      preference:`
		`        matchExpressions:`
		`        - key: another-node-label-key`
		`          operator: In`
		`          values:`
		`          - another-node-label-value`
		`  podAntiAffinity:`
		
		`requiredDuringSchedulingIgnoredDuringExecution:`
		`    - labelSelector:`
		`        matchExpressions:`
		`        - key: app`
		`          operator: In`
		`          values:`
		`          - exampleApp`
		`      topologyKey: "kubernetes.io/hostname"`
		`  podAffinity:`
		
		`preferredDuringSchedulingIgnoredDuringExecution:`
		`     - weight: 50`
		`       podAffinityTerm:`
		`         labelSelector:`
		`           matchExpressions:`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description

		`      - key: app`
		`        operator: In`
		`        values:`
		`          - exampleApp`
		`    topologyKey:`
		`"kubernetes.io/hostname"`

`annotations`	Variable that defines a list of annotations to be applied to a TimesTen Operator Deployment and the Pods that the TimesTen Operator manages.
	There is no default.
		`annotations:`
		`  x: y`

`connectionManager`	Variable that determines if the TimesTen Operator's Connection Manager is used. Values are as follows: • `true` (default): The TimesTen Operator's Connection Manager is used. • `false`: The TimesTen Operator's Connection Manager is not used. See About the Connection Manager.	`connectionManager: true`
`createClusterRole`	Variable that determines if cluster level roles are created. Default: `true` By default or if you specify `true`, the chart creates additional permissions and privileges for the TimesTen Operator. If you specify `false`, the chart does not create the additional permissions and privileges. You must create these objects by running the `kubectl create service_account_cluster.yaml` command. The `service_account_cluster.yaml` YAML manifest file is included in the TimesTen Operator distribution.	`createClusterRole: true`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description

`image`	Variable that defines parameters that affect container images.
	Default:
	• `repository`: Location of the container image. For example, `container-registry.oracle.com/timesten/timesten`.
	• `tag`: TimesTen release number that contains the relevant Helm charts. For example, `"26.1.1.1.0"`.
	• `pullPolicy`: Pull policy for the container image. For example, `Always`.
		`image:`
		`  repository: phx.ocir.io/youraccount/tt2211260image`
		`  tag: "1"`
		`  pullPolicy: Always`

`imagePullSecrets`	Variable that defines a list of pull Secrets required to pull container images. There is no default.	`imagePullSecrets: sekret`
`javaHome`	Variable that defines the location where Java is installed in the TimesTen container image. Default: `"/usr/java/jdk-21"`	`javaHome: "/usr/java/jdk-21"`

`labels`	Variable that defines a list of labels applied to a TimesTen Operator Deployment and the Pods that the TimesTen Operator manages.
	There is no default.
		`labels:`
		`  x: y`

`livenessFailureThreshold`	Variable that sets the `FailureThreshold` attribute for the TimesTen Operator's liveness probe. Default: 3	`livenessFailureThreshold: 2`
`livenessInitialDelaySeconds`	Variable that sets the `InitialDelaySeconds` attribute for the TimesTen Operator's liveness probe. Default: `10`	`livenessInitialDelaySeconds: 15`
`livenessPeriodSeconds`	Variable that sets the `PeriodSeconds` attribute for the TimesTen Operator's liveness probe. Default: `30`	`livenessPeriodSeconds: 20`
`livenessSuccessThreshold`	Variable that sets the `SuccessThreshold` attribute for the TimesTen Operator's liveness probe. Default: 1	`livenessSuccessThreshold: 2`
`livenessTimeoutSeconds`	Variable that sets the `TimeoutSeconds` attribute for the TimesTen Operator's liveness probe. Default: `10`	`livenessTimeoutSeconds: 15`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description
`maxReconciles`	Variable that determines how many TimesTenClassic objects the TimesTen Operator processes concurrently. Valid values are as follows: • `"2"` (default): The TimesTen Operator processes at most two TimesTenClassic objects at one time (in parallel). • `"1"`: The TimesTen Operator processes at most one TimesTenClassic object at one time. For performance purposes, we recommend that you do not change the default value.	`maxReconciles: 2`

`metrics`	Variable that determines if and how TimesTen Operator metrics are exposed.
	Valid values are as follows:
	• `expose: 1` or `expose: 0`: If you specify `expose: 1` (or do not specify it), TimesTen Operator metrics are exposed. If you specify `expose: 0`, TimesTen Operator metrics are not exposed.
	• `scheme: https` or `scheme: http`: If you specify `scheme: https` (or do not specify it), TimesTen Operator metrics are available by using https/Transport Layer Security (mutual TLS). If you specify `scheme: http`, TimesTen Operator metrics are available by using http.
	• `createServiceMonitor: 1` or `createServiceMonitor: 0`: If you specify `createServiceMonitor: 1` (or do not specify it), the TimesTen Operator attempts to create a ServiceMonitor object. If you specify `createServiceMonitor: 0`, the TimesTen Operator does not create a ServiceMonitor object.
	Default:
	`expose: 1`
	`scheme: https`
	`createServiceMonitor: 1`
	See Expose Metrics from the TimesTen Kubernetes Operator.
		`metrics:`
		`  expose: 0`
		`  scheme: http`
		`  createServiceMonitor: 0`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description
`name`	Variable for the name of the TimesTen Operator Deployment. Default: `timesten-operator`	`name: timesten-operator`
`operatorNodePort`	Variable that determines the port on which the Connection Manager is available to applications outside the cluster. The Connection Manager can be accessed from outside the Kubernetes cluster on any node in the Kubernetes cluster by this port number. The default is `32625`. Valid values are between `30000` and `32767`.	`operatorNodePort: 32627`

`operatorSAN`	Variable that adds subject alternate names (SANs) to the TLS certificate that the TimesTen Operator creates to control access to the TimesTen Operator metrics and to the Connection Manager.
	• If you use metrics and the Connection Manager from inside the Kubernetes cluster, you do not need to specify this variable.
	• If you use either metrics or the Connection Manager (or both) from outside the Kubernetes cluster, you must define a SAN for the nodes in the cluster. A SAN value can be a DNS name (potentially wildcarded) or an IP address. The value is a comma delimited list of SAN values.
	You can specify a single level of wildcards.
	By default, there is no SAN specified.
		`operatorSan:`
		`"1.2.3.4,1.2.3.5,*.mycluster.`
		`example.org"`

`podDisruptionBudget`	Variable that determines if a `podDisruptionBudget` is created . If created, uses the provided values.
	Default: `create: false`
	A `podDisruptionBudget` is not created by default.
		`podDisruptionBudget:`
		`  create: true`
		`  pdbName: samplepdb`
		`  maxUnvailable: 1`
		`  minAvailable: 1`
		`  matchLabels:`
		`    "x": "y"`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description

`probes`	Variable that determines if TimesTen Operator probes are exposed.
	If you specify `expose: 1` (or do not specify it), TimesTen Operator probes are exposed. If you specify `expose: 0`, TimesTen Operator probes are not exposed.
	Default:
	`  expose: 1`
	See About Readiness and Liveness Probes.
		`probes:`
		`  expose: 0`

`readinessFailureThreshold`	Variable that sets the `FailureThreshold` attribute for the TimesTen Operator's readiness probe. Default: 1	`readinessFailureThreshold: 2`
`readinessInitialDelaySeconds`	Variable that sets the `InitialDelaySeconds` attribute for the TimesTen Operator's readiness probe. Default: 10	`readinessInitialDelaySeconds: 15`
`readinessPeriodSeconds`	Variable that sets the `PeriodSeconds` attribute for the TimesTen Operator's readiness probe. Default: 10	`readinessPeriodSeconds: 15`
`readinessSuccessThreshold`	Variable that sets the `SuccessThreshold` attribute for the TimesTen Operator's readiness probe. Default: 1	`readinessSuccessThreshold: 2`
`readinessTimeoutSeconds`	Variable that sets the `TimeoutSeconds` attribute for the TimesTen Operator's readiness probe. Default: 10	`readinessTimeoutSeconds: 15`
`replicas`	Variable that defines the number of replica Pods in a TimesTen Operator Deployment. Default: 1	`replicas: 3`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description

`resources`	Variable that defines resource requests and limits.
	Default:
	`  requests:`
	`    cpu: "250m"`
	`    memory: "1G"`
	`  limits:`
	`    cpu: "250m"`
	`    memory: "1G"`
		`resources:`
		`  requests:`
		`    cpu: "300m"`
		`    memory: "1G"`
		`  limits:`
		`    cpu: "300m"`
		`    memory: "1G"`

`serviceAccount`	Variable that determines if a service account is created and what annotations to apply (if any).
	Default: `create: true`
	By default or if you specify `create: true`, the chart creates a Kubernetes ServiceAccount called `timesten-operator` as well as a Kubernetes Role object and a Kubernetes RoleBinding object. The Role and RoleBinding objects grant the ServiceAccount the privileges needed to run the TimesTen Operator.
	If you specify `create: false`, the chart does not create the ServiceAccount, Role, and RoleBinding objects. You must create these objects by running the `kubectl create service_account.yaml` command. The `service_account.yaml` YAML manifest file is included in the TimesTen Operator distribution.
		`serviceAccount:`
		`  create: false`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description

`testAffinity`	Variable that defines Kubernetes `nodeAffinity`, `podAffinity`, and `podAntiAffinity` parameters. These affinity configurations are only applied to the Helm `test` Pod.
	There is no default. However, if you are using a multi-architecture cluster that consists of `amd64` and `arm64` nodes, you must instruct Kubernetes to deploy the TimesTen `test` Pod on a specific architecture. This must be the same architecture as what the TimesTen Operator and its objects run on. For example, if the TimesTen Operator runs on `arm64` nodes, the `test` Pod must also run on `arm64` nodes.
		`testAffinity:`
		`  nodeAffinity:`
		`requiredDuringSchedulingIgnor`
		`edDuringExecution:`
		`      nodeSelectorTerms:`
		`      - matchExpressions:`
		`        - key:`
		`topology.kubernetes.io/zone`
		`          operator: In`
		`          values:`
		`          - antarctica-east1`
		`          - antarctica-west1`
		Here is an example that shows how to instruct Kubernetes to run the `test` Pod on `arm64` nodes:
		`testAffinity:`
		`  nodeAffinity:`
		`requiredDuringSchedulingIgnor`
		`edDuringExecution:`
		`      nodeSelectorTerms:`
		`      - matchExpressions:`
		`        - key:`
		`topology.kubernetes.io/zone`
		`          operator: In`
		`          values: ["arm64"]`
		Valid values for `values` are:
		• `"amd64"`: Use this if you want the `test` Pod to run on `amd64` nodes.
		• `"arm64"`: Use this if you want the `test` Pod to run on `arm64` nodes.

`testAnnotations`	Variable that defines a list of annotations to be applied to a Helm `test` Pod. This Pod is created when you run the `helm test` command.
	Default:
	`helm.sh/hook-delete-policy:`
	`hook-succeeded`
		`testAnnotations:`
		`  x: y`

Table 19-1 (Cont.) Variables for the ttoperator Chart

Variable	Description	Description

`testLabels`	Variable that defines a list of labels to be applied to a Helm `test` Pod. This Pod is created when you run the `helm test` command.
	There is no default.
		```
		testLabels:
		  x: y
		```

The ttclusteroperator Chart

The `ttclusteroperator` chart deploys the TimesTen Operator in the `timesten-operator` namespace in your Kubernetes cluster. The TimesTen Operator runs at cluster-scope and services TimesTenClassic objects in all namespaces in the cluster. The `timesten-operator` namespace is created by the TimesTen Operator and cannot be modified.

The following table describes the variables and default values for the `ttclusteroperator` chart. Indentation and case sensitivity must be correct for each variable. There may be some variables that exist in the product, but are not documented.

Table 19-2 The ttclusteroperator Chart

Variable	Description	Description

`affinity`	Variable that defines Kubernetes `nodeAffinity`, `podAffinity`, and `podAntiAffinity` parameters.
	
	There is no default. However, if you are using a multi-architecture cluster that consists of `amd64` and `arm64` nodes, you must instruct Kubernetes to deploy the TimesTen Operator on a specific architecture.
		```
		affinity:
		  nodeAffinity:

		requiredDuringSchedulingIgnor
		edDuringExecution:
		      nodeSelectorTerms:
		      - matchExpressions:
		        - key:
		topology.kubernetes.io/zone
		          operator: In
		          values:
		          - antarctica-east1
		          - antarctica-west1
		```
		Here is an example that shows how to instruct Kubernetes to deploy the TimesTen Operator and the objects it manages on `arm64` nodes:
		```
		affinity:
		  nodeAffinity:

		requiredDuringSchedulingIgnor
		edDuringExecution:
		      nodeSelectorTerms:
		      - matchExpressions:
		        - key:
		topology.kubernetes.io/zone
		          operator: In
		          values: ["arm64"]
		```
		Valid values for `values` are:
		• `"amd64"`: Use this for TimesTen Operators that you want to run on `amd64` nodes.
		• `"arm64"`: Use this for TimesTen Operators that you want to run on `arm64` nodes.
		Here is a complete affinity section with node affinity and pod affinity sections:
		```
		affinity: {}
		  nodeAffinity:

		requiredDuringSchedulingIgnor
		edDuringExecution:
		      nodeSelectorTerms:
		        - matchExpressions:
		```

Table 19-2   (Cont.) The ttclusteroperator Chart

Variable	Description	Description
		See the code below.

```
          - key:
"kubernetes.io/arch"
            operator: In
            values: ["amd64"]

  nodeAffinity:

requiredDuringSchedulingIgnor
edDuringExecution:
      nodeSelectorTerms:
      - matchExpressions:
        - key:
topology.kubernetes.io/zone
          operator: In
          values:
          - antarctica-east1
          - antarctica-west1

preferredDuringSchedulingIgno
redDuringExecution:
    - weight: 1
      preference:
        matchExpressions:
        - key: another-node-
label-key
          operator: In
          values:
          - another-node-
label-value
  podAntiAffinity:

requiredDuringSchedulingIgnor
edDuringExecution:
    - labelSelector:
        matchExpressions:
        - key: app
          operator: In
          values:
          - exampleApp
      topologyKey:
"kubernetes.io/hostname"
  podAffinity:

preferredDuringSchedulingIgno
redDuringExecution:
     - weight: 50
       podAffinityTerm:
         labelSelector:
           matchExpressions:
```

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description

		`- key: app`
		`  operator: In`
		`  values:`
		`    - exampleApp`
		`topologyKey:`
		`"kubernetes.io/hostname"`

`annotations`	Variable that defines a list of annotations to be applied to a TimesTen Operator Deployment and the Pods that the TimesTen Operator manages.
	There is no default.
		`annotations:`
		`  x: y`

`connectionManager`	Variable that determines if the TimesTen Operator's Connection Manager is used. Values are as follows: • `true` (default): The TimesTen Operator's Connection Manager is used. • `false`: The TimesTen Operator's Connection Manager is not used. See About the Connection Manager.	`connectionManager: true`
`createClusterRole`	Variable that determines if cluster level roles are created. Default: `true` By default or if you specify `true`, the chart creates additional permissions and privileges for the TimesTen Operator. If you specify `false`, the chart does not create the additional permissions and privileges. You must create these objects by running the `kubectl create service_account_cluster.yaml` command. The `service_account_cluster.yaml` YAML manifest file is included in the TimesTen Operator distribution.	`createClusterRole: true`

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description

`image`	Variable that defines parameters that affect container images.
	Default:
	• `repository`: Location of the container image. For example, `container-registry.oracle.com/timesten/timesten`.
	• `tag`: TimesTen release number that contains the relevant Helm charts. For example, `"26.1.1.1.0"`.
	• `pullPolicy`: Pull policy for the container image. For example, `Always`.
		`image:`
		`  repository: phx.ocir.io/youraccount/tt2211260image`
		`  tag: "1"`
		`  pullPolicy: Always`

`imagePullSecrets`	Variable that defines a list of pull Secrets required to pull container images. There is no default.	`imagePullSecrets: sekret`
`javaHome`	Variable that defines the location where Java is installed in the TimesTen container image. Default: `"/usr/java/jdk-21"`	`javaHome: "/usr/java/jdk-21"`

`labels`	Variable that defines a list of labels applied to a TimesTen Operator Deployment and the Pods that the TimesTen Operator manages.
	There is no default.
		`labels:`
		`  x: y`

`livenessFailureThreshold`	Variable that sets the `FailureThreshold` attribute for the TimesTen Operator's liveness probe. Default: 3	`livenessFailureThreshold: 2`
`livenessInitialDelaySeconds`	Variable that sets the `InitialDelaySeconds` attribute for the TimesTen Operator's liveness probe. Default: `10`	`livenessInitialDelaySeconds: 15`
`livenessPeriodSeconds`	Variable that sets the `PeriodSeconds` attribute for the TimesTen Operator's liveness probe. Default: `30`	`livenessPeriodSeconds: 20`
`livenessSuccessThreshold`	Variable that sets the `SuccessThreshold` attribute for the TimesTen Operator's liveness probe. Default: 1	`livenessSuccessThreshold: 2`
`livenessTimeoutSeconds`	Variable that sets the `TimeoutSeconds` attribute for the TimesTen Operator's liveness probe. Default: `10`	`livenessTimeoutSeconds: 15`

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description
`maxReconciles`	Variable that determines how many TimesTenClassic objects the TimesTen Operator processes concurrently. Valid values are as follows: • `"2"` (default): The TimesTen Operator processes at most two TimesTenClassic objects at one time (in parallel). • `"1"`: The TimesTen Operator processes at most one TimesTenClassic object at one time. For performance purposes, we recommend that you do not change the default value.	`maxReconciles: 2`

`metrics`	Variable that determines if and how TimesTen Operator metrics are exposed.
	Valid values are as follows:
	• `expose: 1` or `expose: 0`: If you specify `expose: 1` (or do not specify it), TimesTen Operator metrics are exposed. If you specify `expose: 0`, TimesTen Operator metrics are not exposed.
	• `scheme: https` or `scheme: http`: If you specify `scheme: https` (or do not specify it), TimesTen Operator metrics are available by using https/Transport Layer Security (mutual TLS). If you specify `scheme: http`, TimesTen Operator metrics are available by using http.
	• `createServiceMonitor: 1` or `createServiceMonitor: 0`: If you specify `createServiceMonitor: 1` (or do not specify it), the TimesTen Operator attempts to create a ServiceMonitor object. If you specify `createServiceMonitor: 0`, the TimesTen Operator does not create a ServiceMonitor object.
	Default:
	`expose: 1`
	`scheme: https`
	`createServiceMonitor: 1`
	See Expose Metrics from the TimesTen Kubernetes Operator.
		`metrics:`
		`  expose: 0`
		`  scheme: http`
		`  createServiceMonitor: 0`

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description
`name`	Variable for the name of the TimesTen Operator Deployment. Default: `timesten-operator`	`name: timesten-operator`
`operatorNodePort`	Variable that determines the port on which the Connection Manager is available to applications outside the cluster. The Connection Manager can be accessed from outside the Kubernetes cluster on any node in the Kubernetes cluster by this port number. The default is `32625`. Valid values are between `30000` and `32767`.	`operatorNodePort: 32627`
`operatorSAN`	Variable that adds subject alternate names (SANs) to the TLS certificate that the TimesTen Operator creates to control access to the TimesTen Operator metrics and to the Connection Manager. • If you use metrics and the Connection Manager from inside the Kubernetes cluster, you do not need to specify this variable. • If you use either metrics or the Connection Manager (or both) from outside the Kubernetes cluster, you must define a SAN for the nodes in the cluster. A SAN value can be a DNS name (potentially wildcarded) or an IP address. The value is a comma delimited list of SAN values. You can specify a single level of wildcards. By default, there is no SAN specified.	`operatorSan: "1.2.3.4,1.2.3.5,*.mycluster.example.org"`

`podDisruptionBudget`	Variable that determines if a `podDisruptionBudget` is created . If created, uses the provided values.
	Default: `create: false`
	A `podDisruptionBudget` is not created by default.
		`podDisruptionBudget:`
		`  create: true`
		`  pdbName: samplepdb`
		`  maxUnvailable: 1`
		`  minAvailable: 1`
		`  matchLabels:`
		`    "x": "y"`

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description

`probes`	Variable that determines if TimesTen Operator probes are exposed.
	If you specify `expose: 1` (or do not specify it), TimesTen Operator probes are exposed. If you specify `expose: 0`, TimesTen Operator probes are not exposed.
	Default:
	`  expose: 1`
	See About Readiness and Liveness Probes.
		`probes:`
		`  expose: 0`

`readinessFailureThreshold`	Variable that sets the `FailureThreshold` attribute for the TimesTen Operator's readiness probe. Default: `1`	`readinessFailureThreshold: 2`

`readinessInitialDelaySeconds`	Variable that sets the `InitialDelaySeconds` attribute for the TimesTen Operator's readiness probe.
	Default: `10`
		`readinessInitialDelaySeconds:`
		` 15`

`readinessPeriodSeconds`	Variable that sets the `PeriodSeconds` attribute for the TimesTen Operator's readiness probe. Default: `10`	`readinessPeriodSeconds: 15`
`readinessSuccessThreshold`	Variable that sets the `SuccessThreshold` attribute for the TimesTen Operator's readiness probe. Default: `1`	`readinessSuccessThreshold: 2`
`readinessTimeoutSeconds`	Variable that sets the `TimeoutSeconds` attribute for the TimesTen Operator's readiness probe. Default: `10`	`readinessTimeoutSeconds: 15`
`replicas`	Variable that defines the number of replica Pods in a TimesTen Operator Deployment. Default: `1`	`replicas: 3`

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description
`resources`	Variable that defines resource requests and limits. Default: `requests:` `  cpu: "250m"` `  memory: "1G"` `limits:` `  cpu: "250m"` `  memory: "1G"`	`resources:` `  requests:` `    cpu: "300m"` `    memory: "1G"` `  limits:` `    cpu: "300m"` `    memory: "1G"`
`serviceAccount`	Variable that determines if a service account is created and what annotations to apply (if any). Default: `create: true` By default or if you specify `create: true`, the chart creates a Kubernetes ServiceAccount called `timesten-operator` as well as a Kubernetes Role object and a Kubernetes RoleBinding object. The Role and RoleBinding objects grant the ServiceAccount the privileges needed to run the TimesTen Operator. If you specify `create: false`, the chart does not create the ServiceAccount, Role, and RoleBinding objects. You must create these objects by running the `kubectl create service_account.yaml` command. The `service_account.yaml` YAML manifest file is included in the TimesTen Operator distribution.	`serviceAccount:` `  create: false`

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description

`testAffinity`	Variable that defines Kubernetes `nodeAffinity`, `podAffinity`, and `podAntiAffinity` parameters. These affinity configurations are only applied to the Helm `test` Pod.
	
	There is no default. However, if you are using a multi-architecture cluster that consists of `amd64` and `arm64` nodes, you must instruct Kubernetes to deploy the TimesTen `test` Pod on a specific architecture. This must be the same architecture as what the TimesTen Operator and its objects run on. For example, if the TimesTen Operator runs on `arm64` nodes, the `test` Pod must also run on `arm64` nodes.
		```
		testAffinity:
		  nodeAffinity:

		requiredDuringSchedulingIgnor
		edDuringExecution:
		      nodeSelectorTerms:
		      - matchExpressions:
		        - key:
		topology.kubernetes.io/zone
		          operator: In
		          values:
		          - antarctica-east1
		          - antarctica-west1
		```
		Here is an example that shows how to instruct Kubernetes to run the `test` Pod on `arm64` nodes:
		```
		testAffinity:
		  nodeAffinity:

		requiredDuringSchedulingIgnor
		edDuringExecution:
		      nodeSelectorTerms:
		      - matchExpressions:
		        - key:
		topology.kubernetes.io/zone
		          operator: In
		          values: ["arm64"]
		```
		Valid values for `values` are:
		• `"amd64"`: Use this if you want the `test` Pod to run on `amd64` nodes.
		• `"arm64"`: Use this if you want the `test` Pod to run on `arm64` nodes.

`testAnnotations`	Variable that defines a list of annotations to be applied to a Helm `test` Pod. This Pod is created when you run the `helm test` command.
	
	Default:
	```
	helm.sh/hook-delete-policy:
	hook-succeeded
	```
		```
		testAnnotations:
		  x: y
		```

Table 19-2 (Cont.) The ttclusteroperator Chart

Variable	Description	Description

`testLabels`	Variable that defines a list of labels to be applied to a Helm `test` Pod. This Pod is created when you run the `helm test` command.
	
	There is no default.
		```
		testLabels:
		  x: y
		```

The ttclassic Chart

The `ttclassic` chart creates a TimesTen Classic object.

The following table describes the variables and default values for the `ttclassic` chart. Indentation and case sensitivity must be correct for each variable. The fields are in alphabetical order.

Table 19-3 Variables for the ttclassic Chart

Variable	Default	Example
`additionalMemoryRequest`	Variable that defines the amount of memory to request in addition to what is required for the TimesTen database. This memory is used for the TimesTen daemon, subdaemons, replication agents, cache agents, and the server in a client/server environment. Default: `2Gi` See TimesTenClassicSpecSpec.	`additionalMemoryRequest: 3Gi`

`affinity`	Variable to define Kubernetes `nodeAffinity`, `podAffinity`, and `podAntiAffinity` parameters.
	
	There is no default.
		```
		affinity:
		  nodeAffinity:

		requiredDuringSchedulingIgnor
		edDuringExecution:
		      nodeSelectorTerms:
		      - matchExpressions:
		        - key:
		topology.kubernetes.io/zone
		          operator: In
		          values:
		          - antarctica-east1
		          - antarctica-west1
		```

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`agentTcpTimeout`	Variable that determines the time in seconds that the TimesTen Operator waits for a TCP handshake when communicating with the TimesTen agent. The default is `10`. A value of `0` indicates that there is no timeout. If the timeout is exceeded, the TimesTen Operator considers the agent to be down. See TimesTenClassicSpecSpec.	`agentTcpTimeout: 20`
`agentTlsTimeout`	Variable that determines the time in seconds that the Operator waits for a TLS (https) credential exchange when communicating with the TimesTen agent. The default is `10`. A value of `0` indicates that there is no timeout. If the timeout is exceeded, the TimesTen Operator considers the agent to be down. See TimesTenClassicSpecSpec.	`agentTlsTimeout: 20`

`annotations`	A list of annotations to be applied to a TimesTenClassic object.
	There is no default.
		`annotations:`
		`  x: y`

`clientTLS`	Optional variable used to instruct the TimesTen Operator to automatically generate self-signed certificates and configure TimesTen to use these certificates for client/server TLS encryption.
	For the TimesTen Operator to automatically perform these operations, you must specify `clientTLS` and you must set `clientTLS.auto` to `true`.
	For a list of options and defaults for `clientTLS`, see TimesTenClassicSpecSpecClientTLS.
	For more information about how the TimesTen Operator automatically generates self-signed certificates and configures client/server connections, see Automatically Configure Client/ Server TLS.
		`clientTLS:`
		`  auto: true`
		`  validity: 9999`
		`  encryption: required`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example

`containers`	Variable to define a custom container. This container is created in each Pod in a TimesTenClassic object. The provided YAML is copied directly to the `.spec.template.spec.containers` section of a TimesTenClassic object YAML manifest.
	Default: There is no default.
	See TimesTenClassicSpec.
		`containers:`
		`  - name: sampleapp`
		`    image: sample.com/`
		`sample:26.1.1.1.0`
		`    command:`
		`        - /bin/sample`

`createASReadinessProbe`	Variable that determines if the TimesTen Operator creates a readiness probe for a replicated TimesTenClassic. Valid values: • `true` (default): The TimesTen Operator creates a readiness probe. • `false`: The TimesTen Operator does not create a readiness probe. See About Readiness Probes for TimesTen Containers.	`createASReadinessProbe: true`

`customClientTLS`	Optional variable that instructs the TimesTen Operator to import CA-signed certificates and to configure TimesTen to use these certificates for client/server TLS encryption. Variable optionally instructs the TimesTen Operator to rotate certificates before expiration.
	For a list of options and defaults for `customClientTLS`, see TimesTenClassicSpecSpecCustomClientTLS.
	For more information about how the TimesTen Operator imports and rotates CA-signed certificates, see Use CA-Signed Certificates for Client/Server TLS Encryption.
		`customClientTLS:`
		`  serverCert: server-secret-`
		`name`
		`  ciphersuites:`
		`SSL_ECDHE_ECDSA_WITH_AES_128_`
		`GCM_SHA256`
		`  encryption: required`
		`  gracePeriod: 90`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example

`customerService[1-5]`	Variable to create one or more Services (up to 5). A Service maps to your TimesTen database, which allows applications outside of your Kubernetes cluster to access TimesTen through client/server.
	You can define a maximun of five custom Services, named `customService1`, `customService2`, `customService3`, `customService4`, and `customService5`.
	Note The YAML that you provide for a `customService` definition is used without modification.
	Default: There is no default.
		`customService1:`
		`  apiVersion: v1`
		`  kind: Service`
		`  metadata:`
		`    name: sampleexternal`
		`  spec:`
		`    type: NodePort`
		`    selector:`
		`database.timesten.oracle.com:`
		` payroll`
		`    ports:`
		`      - port: 6625`
		`        targetPort: 6625`
		`        nodePort: 31625`
		
		`customService2:`
		`  apiVersion: v1`
		`  kind: Service`
		`  metadata:`
		`    name: sampleinteral`
		`  spec:`
		`    type: NodePort`
		`    selector:`
		`database.timesten.oracle.com:`
		` payroll`
		`    ports:`
		`      - port: 6626`
		`        targetPort: 6626`
		`        nodePort: 31626`

`daemonLogCPURequest`	Amount of CPU requested for the `daemonlog` container. Default: `200m` See TimesTenClassicSpecSpec.	`daemonlogCPURequest: 400m`
`daemonLogMemoryRequest`	Amount of memory requested for the `daemonlog` container. Default: `200Mi` See TimesTenClassicSpecSpec.	`daemonLogMemoryRequest: 300Mi`
`databaseCPURequest`	Amount of CPU your `tt` containers require. This includes the CPU used by the TimesTen daemon, subdaemons, replication agents, cache agents, and the server in a client/server environment. Default: There is no default. See TimesTenClassicSpecSpec.	`databaseCPURequest: 2`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`databaseMemorySize`	Amount of shared memory your database requires. Default: There is no default. See TimesTenClassicSpecSpec.	`databaseMemorySize: 20Gi`

`dbConfigMap`	Variable that creates a Kubernetes ConfigMap based on the provided values and adds a `dbConfigMap` entry to a TimesTenClassic object definition.
	Default: There is no default. By default, a ConfigMap is not created by a `ttclassic` chart.
	See TimesTenClassicSpecSpec.
		`dbConfigMap:`
		`  - name: sample`
		`    directory: cm`
		
		Note: You must create a directory in the `/ttclassic` directory of the `ttclassic` chart. All files in the directory are added to the generated ConfigMap. This example assumes you have created a `cm` directory in the `/ttclassic` directory tree.

`dbSecret`	Variable that creates a Kubernetes Secret based on the provided values and adds a `dbSecret` entry to a TimesTenClassic object definition.
	Default: There is no default. By default, a Secret is not created by a `ttclassic` chart.
	See TimesTenClassicSpecSpec.
		`dbSecret:`
		`  - name: sample`
		`    directory: seekret`
		
		Note: You must create a directory in the `/ttclassic` directory of the `ttclassic` chart. All files in the directory are added to the generated Secret. This example assumes you have created a `seekret` directory in the `/ttclassic` directory tree.

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`deleteDbOnNotReadyNode`	When specified, this variable directs the TimesTen Operator to detect situations where a Node is not ready (or unknown) for a specific period of time. When detected, the TimesTen Operator takes appropriate action to remedy the situation. Specifically, the TimesTen Operator checks to see if the Node's not ready condition has existed for more than `deleteDbOnNotReadyNode` seconds. If so, the TimesTen Operator deletes the Pod and the PVCs associated with the Pod. This causes Kubernetes to create a new Pod and new PVCs on a surviving Node. Once the Pod is scheduled and started by Kubernetes, the TimesTen Operator configures it as usual. The value is expressed in seconds and must be greater than `pollingInterval`. By default, this variable is not specified. You must specify it. Note: Use caution when specifying this datum. Specifying this datum could result in the TimesTen Operator deleting PVCs. Deleting PVCs discards the on-disk copy of TimesTen databases. For more information, see How the TimesTen Kubernetes Operator Handles Node Failure.	`deleteDbOnNotReadyNode: 30`
`exporterCPURequest`	Amount of CPU requested for the `exporter` container (if provisioned). Default: `200m` See TimesTenClassicSpecSpec.	`exporterCPURequest: 400m`
`exporterMemoryRequest`	Amount of memory requested for the `exporter` container (if provisioned). Default: `200Mi`	`exporterMemoryRequest: 400Mi`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example

`image`	Parameters that affect container images.
	Default:
	• `repository`: Location of the container image. For example, `container-registry.oracle.com/timesten/timesten`.
	• `tag`: TimesTen release number that contains the relevant Helm charts. For example, `"26.1.1.1.0"`.
	• `pullPolicy`: Pull policy for the container image. For example, `Always`.
		`image:`
		`  repository: phx.ocir.io/youraccount/tt2211260image`
		`  tag: "1"`
		`  pullPolicy: Always`

`imagePullSecret`	Pull Secret required to pull container images. Default: There is no default. See TimesTenClassicSpecSpec.	`imagePullSecret: sekret`
`imageUpgradeStrategy`	Variable to determine if the TimesTen Operator performs automated upgrades. If set to `Manual`, Helm cannot automatically upgrade or rollback a release. Default: `Auto` See TimesTenClassicSpecSpec.	`imageUpgradeStrategy: Manual`

`initContainers`	Variable used to define an `init` container. This `init` container is created in each Pod in a TimesTenClassic object.
	The provided YAML is copied directly to the `.spec.template.spec` section of a TimesTenClassic object YAML manifest.
	Default: There is no default.
		`initContainers:`
		`- name: sample`
		`  image:`
		`  command:`
		`  - sh`
		`  - "-c"`
		`  - |`
		`    /bin/bash <<'EOF'`
		`    echo test/user > /ttconfig/testUser`
		`    ls -l /ttconfig`
		`    EOF`
		`  volumeMounts:`
		`  - name: tt-config`
		`    mountPath: /ttconfig`

`labels`	A list of labels to be applied to a TimesTenClassic object.
	Default: There is no default.
		`labels:`
		`  x: y`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`logStorageClassName`	Name of the storage class that is used to request persistent volumes for the TimesTen database transaction log files. Default: There is no default. If you do not specify `logStorageClassName`, a log volume is not allocated. See TimesTenClassicSpecSpec.	`logStorageClassName: fast`
`logStorageSize`	Amount of storage to be provisioned for the TimesTen transaction log files. Default: `50Gi` See TimesTenClassicSpecSpec.	`logStorageSize: 100Gi`
`name`	Name of the TimesTenClassic object to be created. Default: `releaseName`	`name: sample`

`podDisruptionBudget`	Variable that determines if a `podDisruptionBudget` is created . If created, uses the provided values.
	Default: `create: false`
	A `podDisruptionBudget` is not created by default.
		`podDisruptionBudget:`
		`  create: true`
		`  pdbName: samplepdb`
		`  maxUnvailable: 1`
		`  minAvailable: 1`
		`  matchLabels:`
		`    "x": "y"`

`pollingInterval`	Variable that determines how often (expressed in seconds) that the TimesTen Operator checks the status of a TimesTenClassic object. Default: 5	`pollingInterval: 6`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`readOnlyRootFilesystem`	Variable that determines if the TimesTen Operator causes the container image to be mounted read only in TimesTen containers. The TimesTen Operator provisions an empty directory and mounts it on top of the `/tmp` directory in all TimesTen containers in all TimesTen Pods. This includes the `tt`, `daemonlog`, and `exporter` containers in each Pod. Valid values: • `true` (default): The TimesTen Operator provisions an empty directory and mounts it on top of the `/tmp` directory. In addition, the TimesTen Operator creates these containers with container images mounted as read-only. • `false`: The TimesTen Operator does not provision an empty directory and does not create containers with container images mounted as read-only. If you provide your own containers, the TimesTen Operator does not automatically mount your container images as read-only. If you upgrade a `v1` TimesTenClassic object and if the Pods associated with that TimesTenClassic object are replaced, the replacements do not have `readOnlyRootFilesystem` set.	`readOnlyRootFilesystem: true`
`replicas`	Variable that determines the number of Pods to provision for a non-replicated TimesTenClassic object. The default is 1. The maximum value is 3.	`replicas: 2`

`replicationTopology`	Variable that determines the configuration for a TimesTen Classic database.
	Valid values:
	• `activeStandbyPair` (default): The TimesTen Operator configures an active standby pair replication scheme.
	• `none`: The TimesTen Operator does not configure replication. Instead, it configures a non-replicated configuration and uses the `replicas` variable to determine how many TimesTen Pods to create.
		`replicationTopology: activeStandbyPair`
		or
		`replicationTopology: none`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`repStateTimeout`	Variable that indicates the time in seconds a replicated database remains in the `recovering` replication state as reported by the TimesTen `ttRepStateGet` built-in procedure. The `recovering` replication state indicates that the database is in the process of synchronizing updates with the active database after a failure. For more information about the TimesTen `ttRepStateGet` built-in procedure, see ttRepStateGet in the *Oracle TimesTen In-Memory Database Reference*. Default: `30` (expressed in seconds). For more information about `repStateTimeout`, see TimesTenClassicSpecSpec.	`repStateTimeout: 40`
`rollingUpdatePartition`	Variable that is specific to upgrading a non-replicated configuration. Kubernetes upgrades Pods with an ordinal value that is greater than or equal to the `rollingUpdatePartition` value. For example, if you have three non-replicated Pods (`replicas` = 3 and Pods are `samplerep-0`, `samplerep-1`, and `samplerep-2`) and you set `rollingUpdatePartition` to `1`, the `samplerep_1` and `samplerep-2` Pods are upgraded, but the `samplerep-0` Pod is not. The default is `0`. For more information, see Perform Upgrades in this book and Partitioned rolling updates in the Kubernetes documentation.	`rollingUpdatePartition: 2`

`securityContext`	Variable used to create an optional `securityContext` definition. This `securityContext` definition is applied to TimesTenClassic at the Pod level.
	The provided YAML is copied directly to the `.spec.template.spec` section of a TimesTenClassic object YAML manifest.
	Default: There is no default.
		`securityContext`
		`  runAsNonRoot: true`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`serviceAccountName`	Name of the service account that is assigned to the Pods that are created by the TimesTen Operator. By default, when the TimesTen Operator creates StatefulSets (which in turn create Pods that run TimesTen), the StatefulSets and Pods have no service account. Specifying `serviceAccountName` lets you define a Kubernetes ServiceAccount that the TimesTen Pods run under. Default: There is no default.	`serviceAccountName: xyz`
`storageClassName`	Name of the storage class that is used to request persistent volumes for a TimesTen database. Default: There is no default. However, you must specify a value for `storageClassName`. See TimesTenClassicSpecSpec.	`storageClassName: oci-bv`
`storageSize`	Amount of storage to be provisioned for TimesTen and the TimesTen database. Default: `50Gi`	`storageSize: 250Gi`

`storePassword`	The TimesTen Operator stores its security certificates in Java Keystores. In order to create and use Java Keystores, they must be secured with a known password (`storePassword`). The password must be known by both the TimesTen Operator who creates and reads the keystore and the TimesTen Agent who also reads it.
	The default value is a hard-coded string that is not documented.
	Although not recommended, you can use the `storePassword` variable to set the password to a different value than the default and control the password setting. Once set, you cannot change `storePassword`. If it is changed, the TimesTen Operator generates a warning in the form of a Kubernetes Event and ignores the changed value.
		`storePassword:`
		`pseudoRandomString`

`templateSpec`	Variable used to insert arbitrary YAML into the `.spec.template.spec` section of a TimesTenClassic object.
	Default: There is no default.
	See TimesTenClassicSpec.
		`templateSpec:`
		`  preemptionPolicy: Never`

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example
`terminationGracePeriod`	Variable that determines the amount of time (in seconds) that Kubernetes waits for a Pod to gracefully shut down before being forcefully terminated. The default varies depending on your configuration: • Replicated (Active Standby Pair: Default) is `10` seconds. • Non-replicated: Default is `300` seconds.	`terminationGracePeriod: 30`

`testAffinity`	Variable to define Kubernetes `nodeAffinity`, `podAffinity`, and `podAntiAffinity` parameters. These affinity configurations are only applied to the Helm `test` Pod.
	There is no default.
		```
		testAffinity:
		  nodeAffinity:

		requiredDuringSchedulingIgnoredDuringExecution:
		      nodeSelectorTerms:
		      - matchExpressions:
		        - key:
		topology.kubernetes.io/zone
		          operator: In
		          values:
		          - antarctica-east1
		          - antarctica-west1
		```

`testAnnotations`	A list of annotations to be applied to a Helm `test` Pod. This Pod is created when you run the `helm test` command.
	Default:
	`helm.sh/hook-delete-policy: hook-succeeded`
		```
		testAnnotations:
		  x: y
		```

`testLabels`	A list of labels to be applied to a Helm `test` Pod. This Pod is created when you run the `helm test` command.
	Default: There is no default.
		```
		testLabels:
		  x: y
		```

`tolerations`	Variable to define tolerations to be applied to the Pods in a TimesTenClassic object.
	The provided YAML is copied directly to the `.spec.template.spec` section of a TimesTenClassic object YAML manifest.
	Default: There is no default.
		```
		tolerations:
		  - key: "key1"
		    operator: "Equal"
		    value: "value1"
		    effect: "NoSchedule"
		```

Table 19-3 (Cont.) Variables for the ttclassic Chart

Variable	Default	Example

`ttspec`	Variable to insert arbitrary YAML into the `.spec.ttspec` section of a TimesTenClassic object. Use this variable to specify additional datum that are supported by the TimesTenClassic object type, but are not explicitly supported by the `ttclassic` chart.
	Default: There is no default.
	See TimesTenClassicSpecSpec.
		```
		ttspec:
		  agentGetTimeout: 10
		  prometheus:
		    port: 7777
		```

`volumes`	Variable used to create optional `volume` definitions. These definitions are applied to TimesTenClassic objects.
	The provided YAML is copied directly to the `.spec.template.spec` section of a TimesTenClassic object YAML manifest.
	Default: There is no default.
		```
		volumes:
		  - name: tt-config
		    emptyDir: {}
		```

20 TimesTen Kubernetes Operator Metrics

There are several TimesTen Kubernetes Operator (TimesTen Operator) metrics that can be exposed and then published by Prometheus or some other scraper. These metrics include information about the functionality of the TimesTen Operator as well as the overall status of TimesTenClassic objects that the TimesTen Operator manages.

The following table details the TimesTen Operator metrics:

Table 20-1 TimesTen Operator Metrics

Metric	Type	Description
`timesten_active_node`	Gauge	Node containing the active TimesTen database.
`timesten_agent_rss`	Gauge	Resident Set Size (rss) for the TimesTen Agent within each Pod running TimesTen. Reports the value as reported by the `VmRSS` field in the `/proc/self/status` file, which is managed by the Linux kernel for the TimesTen agent process within each `tt` container in each Pod that is running TimesTen. Reports the value in Kilobytes.
`timesten_agent_tt_mem_usage`	Gauge	Amount of memory used by the TimesTen Agent and TimesTen within a Pod. Reports the memory usage by each Pod as reported by Linux cgroups in the `memory.usage_in_bytes` value. Reports the value in bytes.
`timesten_classic_state`	Gauge	State of each TimesTenClassic object. The specific state is reported in the `state` label.
`timesten_classic_state_allreplicasready`	Gauge	Number of non-replicated TimesTenClassic objects in the `AllReplicasReady` state.
`timesten_classic_state_noreplicasready`	Gauge	Number of non-replicated TimesTenClassic objects in the `NoReplicasReady` state.
`timesten_classic_state_normal`	Gauge	Number of replicated TimesTenClassic objects in the `Normal` state.
`timesten_classic_state_not_allreplicasready`	Gauge	Number of non-replicated TimesTenClassic objects in states other than `AllReplicasReady` or `Initializing`.
`timesten_classic_state_not_normal`	Gauge	Number of replicated TimesTenClassic objects in states other than `Normal` or `Initializing`.

Table 20-1 (Cont.) TimesTen Operator Metrics

Metric	Type	Description
`timesten_classic_state_somereplicasready`	Gauge	Number of non-replicated TimesTenClassic objects in the `SomeReplicasReady` state.
`timesten_pods_deleted_unschedulable`	Gauge	Total count of Pods that the TimesTen Operator has deleted. The value increases each time a Pod is deleted. For more information, see the `deleteDbOnNotReadyNode` datum in Table 18-3.
`timesten_pods_unschedulable`	Gauge	Number of Pods that are not currently scheduled by Kubernetes. The value increases and decreases over time.
`timesten_pvcs_deleted_unschedulable`	Gauge	Total count of PVCs that the TimesTen Operator has deleted. The value increases each time a PVC is deleted. For more information, see the `deleteDbOnNotReadyNode` datum in Table 18-3.
`timesten_operator_mem_usage`	Gauge	Amount of memory used by the TimesTen Kubernetes Operator. Reports the memory usage by the TimesTen Operator Pod as reported by Linux cgroups in the `memory.usage_in_bytes` value. Reports the value in bytes.
`timesten_operator_rss`	Gauge	Resident Set Size (rss) for the TimesTen Kubernetes Operator. Reports the value as reported by the `VmRSS` field in the `/proc/self/status` file, which is managed by the Linux kernel for the TimesTen Kubernetes Operator process. Reports the value in Kilobytes.
`timesten_standby_node`	Gauge	Node containing the standby TimesTen database.

Each metric has these labels:

- `namespace`: The namespace of the TimesTen object that the metric describes.
- `name`:
  - For the `timesten_operator_mem_usage` and `timesten_operator_rss` metrics, the name label is the name of the TimesTen Operator Pod.
  - For the `timesten_agent_tt_mem_usage` and `timesten_agent_rss` metrics, the name label is the name of the TimesTen Pod.
  - For all other metrics, the name label is the name of the TimesTen object that the metric describes.

In addition there are several other labels of secondary importance:

- `container`: The name of the container that generated the metric. For example, `timesten-operator`.

- `endpoint`: The name of the endpoint that the metric came from. For example, `metrics`.
- `instance`: The IP address and port of the TimesTen Operator Pod that generated the metric. For example, `10.244.1.111:8080`
- `job`: The name of the job. For example, `timesten-operator`.
- `pod`: The name of the TimesTen Operator Pod that generated the metric. For example, `timesten-operator-5f4f4c69f6-z9h2k`.
- `service`. The name of the Service. For example, `timesten-operator`.

Here is an example of a sample `timesten_classic_state_normal` metric:

```
timesten_classic_state_normal{container="timesten-operator",
endpoint="metrics", instance="10.244.1.111:8080", job="timesten-operator",
name="sample", namespace="mynamespace", pod="timesten-operator-5f4f4c69f6-
z9h2k",
service="timesten-operator"}
```

The metric has a value of `1` or `0`, depending on whether the TimesTenClassic object (`sample`, in this case) is healthy or not.

Here is an example of a sample `timesten_classic_state` metric:

```
timesten_classic_state{container="timesten-operator",
endpoint="metrics", instance="10.244.1.111:8080", job="timesten-operator",
name="sample", namespace="mynamespace", pod="timesten-operator-5f4f4c69f6-
z9h2k",
service="timesten-operator", state="Normal"}
```

The metric has a value of `1` or `0`, depending on whether the TimesTenClassic object (`sample`, in this case) is in the `Normal` state or not.

For details on how the TimesTen Operator exposes metrics, see Expose Metrics from the TimesTen Kubernetes Operator.

Note

The TimesTen Operator automatically exposes many other additional metrics. We cannot guarantee these additional metrics will exist from release to release. In addition, these metrics may not be specifically pertinent or useful for the TimesTen Operator.

21 TimesTen Kubernetes Operator Environment Variables

There are environment variables for the TimesTen Operator. The `operator.yaml` and `cluster_operator.yaml` files contain these environment variables. You can change the default setting for these environment variables depending on your needs. For more information about the TimesTen Operator, see About the TimesTen Operator.

The following table describes these variables:

Table 21-1 TimesTen Operator Environment Variables

Environment Variable	Description
`CREATE_SERVICEMONITOR`	Determines if the TimesTen Operator creates a Kubernetes ServiceMonitor object. Valid values are as follows: • `"1"` (default): The TimesTen Operator should create a ServiceMonitor object. • `"0"`: The TimesTen Operator should not create a ServiceMonitor object. If `EXPOSE_METRICS` is set to `"0"` and `CREATE_SERVICEMONITOR` is set to `"1"` (default), `CREATE_SERVICEMONITOR` is treated as though it was set to `"0"`. See Expose Metrics from the TimesTen Kubernetes Operator.
`EXPOSE_METRICS`	Determines if TimesTen Operator metrics are exposed outside of the TimesTen Operator's Pods. Valid values are as follows: • `"1"` (default): Metrics should be exposed outside of the TimesTen Operator's Pods. • `"0"`: Metrics should not be exposed outside of the TimesTen Operator's Pods. If `EXPOSE_METRICS` is set to `"0"` and `CREATE_SERVICEMONITOR` is set to `"1"` (default), `CREATE_SERVICEMONITOR` is treated as though it was set to `"0"`. In addition, if `EXPOSE_METRICS` is set to `"0"`, the value of `METRICS_SCHEME` is ignored and http is always used. See Expose Metrics from the TimesTen Kubernetes Operator.
`EXPOSE_PROBES`	Determines if liveness probes should be exposed outside of the TimesTen Operator's Pods. Valid values are as follows: • `"1"` (default): Probes should be exposed. • `"0"`: Probes should not be exposed.

Table 21-1 (Cont.) TimesTen Operator Environment Variables

Environment Variable	Description
`JAVA_HOME`	Specifies the location where Java is installed in the TimesTen container image. Default: `/usr/java/jdk-21` If you are using a different location, change the value for this environment variable.
`METRICS_SCHEME`	Determines if TimesTen Operator metrics should be made available by https or http. Valid values are as follows: • `"https"` (default): https is used. • `"http"`: http is used. If `EXPOSE_METRICS` is set to `"0"`, the value of `METRICS_SCHEME` is ignored and http is always used. See Expose Metrics from the TimesTen Kubernetes Operator.
`TT_CONNECTION_MANAGER`	Determines if the TimesTen Operator's Connection Manager is enabled. Valid values are as follows: • `"1"` (default): Enable the Connection Manager. • `"0"`: Do not enable the Connection Manager. If you disable metrics for the TimesTen Operator or you do not use https for metrics, the Connection Manager is not enabled. For example, if you set `METRICS_SCHEME` to `"http"` or `EXPOSE_METRICS` to `"0"`, then `TT_CONNECTION_MANAGER` is ignored and treated as `"0"`. See About the Connection Manager.
`TT_CONNECTION_MANAGER_NODEPORT`	Determines the port number on which the Connection Manager is available to applications outside of the Kubernetes cluster. The Connection Manager can be accessed from outside the Kubernetes cluster on any node in the Kubernetes cluster by this port number. The default is `32625`. Valid values are between `30000` and `32767`. Use this environment variable to change the port number.
`TT_MAX_RECONCILES`	Determines how many TimesTenClassic objects the TimesTen Operator processes concurrently. Valid values are as follows: • `"2"` (default): The TimesTen Operator processes at most two TimesTenClassic objects at one time (in parallel). • `"1"`: The TimesTen Operator processes at most one TimesTenClassic object at one time. For performance purposes, we recommend that you do not change the default value.

Table 21-1 (Cont.) TimesTen Operator Environment Variables

Environment Variable	Description
`TT_OPERATOR_SAN`	Adds subject alternate names (SANs) to the TLS certificate that the TimesTen Operator creates to control access to the TimesTen Operator metrics and to the Connection Manager. • If you use metrics and the Connection Manager from inside the Kubernetes cluster, you do not need to set this environment variable. • If you use either metrics or the Connection Manager (or both) from outside the Kubernetes cluster, you must define a SAN for the nodes in the cluster. A SAN value can be a DNS name (potentially wildcarded) or an IP address. The value is a comma delimited list of SAN values, such as `"1.2.3.4,1.2.3.5,*.mycluster.example.org"`. You can specify a single level of wildcards. By default, there is no SAN specified.

22 Dockerfile ARGs

You have several options for obtaining TimesTen container images. One of these options is to build your own TimesTen container image. TimesTen provides a Dockerfile for this purpose. For more information about TimesTen container images, see About TimesTen Container Images and Container Registry Options.

The Dockerfile supports a number of ARGs. These ARGs let you override the attributes of the Dockerfile (and its resultant image). You supply these ARGs on the `docker build` command line.

The following table describes the supported ARGs:

Table 22-1 Dockerfile ARGs

ARG name	Default value	Description
`TT_BASE`	`container-registry.oracle.com/os/oraclelinux:9`	Name of the base image.
`TT_DISTRO`	`timesten26.1.1.1.0.server.linux8664.zip` or `timesten26.1.1.1.0.server.linuxarm64.zip` depending on whether you are using `amd64` or `arm64` nodes.	Name of the TimesTen distribution that you are including in the container image. For information about deploying the TimesTen Kubernetes Operator in a multi-architecture Kubernetes cluster, see About Deploying in a Multi-Architecture Kubernetes Cluster.
`TT_EXTRA_LINUX_PACKAGES`	There is no default.	Additional Linux packages that you want installed in the container image by the `yum install` command.
`TT_GID`	`3429`	The numeric GID of `$TT_GROUP`. To define a different GID for `$TT_GROUP`, supply this ARG on the `docker build` command line.
`TT_GROUP`	`timesten`	Name of the Linux group that is created in the container image. This is the name of the TimesTen users group. To define a different name for the TimesTen group, supply this ARG on the `docker build` command line.
`TT_RELEASE`	`26.1.1.1.0`	Release number (in dotted decimal format) of the TimesTen release that is included in `$TT_DISTRO`.
`TT_UID`	`3429`	The numeric UID of `$TT_USER`. To define a different UID for `$TT_USER`, supply this ARG on the `docker build` command line.

Table 22-1 (Cont.) Dockerfile ARGs

ARG name	Default value	Description
`TT_USER`	`timesten`	Name of the Linux user that is created in the container image. This is the user who runs TimesTen. To define a different user to run TimesTen, supply this ARG on the `docker build` command line.
`UNZIP_BASE`	`container-registry.oracle.com/os/oraclelinux:9`	Name of the image that is used to unzip the TimesTen distribution.

A

Active Standby Pair Example

This appendix provides an example showing you the complete process for deploying and running your active standby pair of TimesTen databases in the Kubernetes cluster. After the databases are up and running, the example demonstrates how the Operator controls and manages the databases. If the active database fails, the Operator performs the necessary tasks to failover to the standby database, making that standby database the active one. The example concludes with procedures to delete the TimesTen databases and to stop the Operator.

Note

You have the option of using Helm to deploy your active standby pair of TimesTen databases. For more information about using Helm, see Use Helm in Your TimesTen Kubernetes Operator Environment.

- Before You Begin
- Create a ConfigMap Object
- Create a TimesTenClassic Object
- Monitor Deployment
- Verify Existence of Underlying Objects
- Verify Connection to the Active TimesTen Database
- Recover from Failure
- Clean Up

Before You Begin

Review the following sections and complete if you have not already done so.

1. Before You Begin
2. Prepare to Use the TimesTen Kubernetes Operator
3. Install the TimesTenClassic Custom Resource Definition
4. Learn About and Install the TimesTen Kubernetes Operator

Create a ConfigMap Object

This section creates the `sample` ConfigMap. This ConfigMap contains the `db.ini`, the `adminUser`, and the `schema.sql` metadata files. This ConfigMap will be referenced when you define the TimesTenClassic object. See "Overview of Configuration Metadata and Kubernetes Facilities" for information on the configuration files and the ConfigMap facility.

On your Linux development host:

1. From the directory of your choice, create an empty subdirectory for the metadata files. This example creates the `cm_sample` subdirectory. (The `cm_sample` directory is used in the remainder of this example to denote this directory.)

   ```
   % mkdir -p cm_sample
   ```

2. Create the `db.ini` file in this ConfigMap directory (`cm_sample`, in this example). In this `db.ini` file, define the `PermSize` and `DatabaseCharacterSet` connection attributes.

   ```
   vi cm/db.ini

   PermSize=200
   DatabaseCharacterSet=AL32UTF8
   ```

3. Create the `adminUser` file in this ConfigMap directory (`cm_sample` in this example). In this `adminUser` file, create the `sampleuser` user with the `samplepw` password.

   ```
   vi cm/adminUser

   sampleuser/samplepw
   ```

4. Create the `schema.sql` file in this ConfigMap directory (`cm_sample` in this example). In this `schema.sql` file, define the `s` sequence and the `emp` table for the `sampleuser` user. The Operator will automatically initialize your database with these object definitions.

   ```
   vi cm/schema.sql

   create sequence sampleuser.s;
   create table sampleuser.emp (
     id number not null primary key,
     name char(32)
   );
   ```

5. Create the ConfigMap. The files in the `cm_sample` directory are included in the ConfigMap and, later, will be available in the TimesTen containers.

   In this example:

   - The name of the ConfigMap is `sample`. Replace `sample` with a name of your choosing. (`sample` is represented in **bold** in this example.)
   - This example uses `cm_sample` as the directory where the files that will be copied into the ConfigMap reside. If you use a different directory, replace `cm_sample` with the name of your directory. (`cm_sample` is represented in **bold** in this example.)

   Use the `kubectl create` command to create the ConfigMap:

   ```
   % kubectl create configmap sample --from-file=cm_sample
   configmap/sample created
   ```

   You successfully created and deployed the `sample` ConfigMap.

6. Use the `kubectl describe` command to verify the contents of the ConfigMap. (`sample`, in this example.)

   ```
   % kubectl describe configmap sample
   Name:         sample
   Namespace:    mynamespace
   Labels:       <none>
   Annotations:  <none>

   Data
   ====
   adminUser:
   ----
   ```

```
sampleuser/samplepw

db.ini:
----
PermSize=200
DatabaseCharacterSet=AL32UTF8

schema.sql:
----
create sequence sampleuser.s;
create table sampleuser.emp (
  id number not null primary key,
  name char(32)
);


Events:  <none>
```

Create a TimesTenClassic Object

This section creates the TimesTenClassic object. For detailed information about the TimesTenClassic object type, see Syntax for the TimesTenClassic Object Type.

Perform these steps:

1. Create an empty YAML file. You can choose any name, but you may want to use the same name you used for the name of the TimesTenClassic object. (In this example, `sample`.) The YAML file contains the definitions for the TimesTenClassic object. See "TimesTenClassicSpecSpec" for information on the fields that you must specify in this YAML file as well as the fields that are optional.

   In this example, replace the following. (The values you can replace are represented in **bold**.)

   - `name`: Replace `sample` with the name of your TimesTenClassic object.
   - `storageClassName`: Replace `oci-bv` with the name of the storage class used to allocate PersistentVolumes to hold TimesTen.
   - `storageSize`: Replace `250Gi` with the amount of storage that should be requested for each Pod to hold TimesTen. Note: This example assumes a production environment and uses a value of `250Gi` for `storageSize`. For demonstration purposes, a value of `50Gi` is adequate. See the `storageSize` and the `logStorageSize` entries in "Table 18-3" for information.
   - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` with the location and name of your image.
   - `imagePullSecret`: Replace `sekret` with the image pull secret that Kubernetes should use to fetch the TimesTen image.
   - `dbConfigMap`: This example uses one ConfigMap (called `sample`) for the `db.ini`, the `adminUser`, and the `schema.sql` metadata files. This ConfigMap will be included in the ProjectedVolume. This volume is mounted as `/ttconfig` in the TimesTen containers. See "Using ConfigMaps and Secrets" and "Example Using One ConfigMap" for information on ConfigMaps.

   ```
   % vi sample.yaml

   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   metadata:
   ```

```
  name: sample
spec:
  ttspec:
    storageClassName: oci-bv
    storageSize: 250Gi
    image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    imagePullSecret: sekret
    dbConfigMap:
    - sample
```

2. Use the `kubectl create` command to create the TimesTenClassic object from the contents of the YAML file (in this example, `sample.yaml`). Doing so begins the process of deploying your active standby pair of TimesTen databases in the Kubernetes cluster.

```
% kubectl create -f sample.yaml
configmap/sample created
timestenclassic.timesten.oracle.com/sample created
```

You successfully created the TimesTenClassic object in the Kubernetes cluster. The process of deploying your TimesTen databases begins, but is not yet complete.

Monitor Deployment

Use the `kubectl get` and the `kubectl describe` commands to monitor the progress of the active standby pair as it is provisioned.

Note

For the `kubectl get timestenclassic` and `kubectl describe timestenclassic` commands, you can alternatively specify `kubectl get ttc` and `kubectl describe ttc` respectively. `timestenclassic` and `ttc` are synonymous when used in these commands, and return the same results. The first `kubectl get` and the first `kubectl describe` examples in this appendix use `timestenclassic`. The remaining examples in this appendix use `ttc` for simplicity.

1. Use the `kubectl get` command and review the `STATE` field. Observe the value is `Initializing`. The active standby pair provisioning has begun, but is not yet complete.

```
% kubectl get timestenclassic sample
NAME     STATE          ACTIVE   AGE
sample   Initializing   None     11s
```

2. Use the `kubectl describe` command to view the initial provisioning in detail.

```
% kubectl describe timestenclassic sample
Name:         sample
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>
API Version:  timesten.oracle.com/v4
Kind:         TimesTenClassic
Metadata:
  Creation Timestamp:  2025-01-16T15:35:12Z
  Generation:          1
  Resource Version:    20251755
  Self Link:
/apis/timesten.oracle.com/v4/namespaces/mynamespace/timestenclassics/sample
  UID:                 517a8646-a354-11ea-a9fb-0a580aed5e4a
```

```
Spec:
  Ttspec:
    Db Config Map:
      sample
    Image:                container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    Image Pull Policy:    Always
    Image Pull Secret:    sekret
    Storage Class Name:   oci-bv
    Storage Size:         250Gi
Status:
  Active Pods:        None
  High Level State:   Initializing
  Last Event:         3
  Pod Status:
    Cache Status:
      Cache Agent:        Down
      Cache UID Pwd Set:  false
      N Cache Groups:     0
    Db Status:
      Db:            Unknown
      Db Id:         0
      Db Updatable:  Unknown
    Initialized:     true
    Pod Status:
      Agent:                Down
      Last Time Reachable:  0
      Pod IP:
      Pod Phase:            Pending
    Replication Status:
      Last Time Rep State Changed:  0
      Rep Agent:                    Down
      Rep Peer P State:             Unknown
      Rep Scheme:                   Unknown
      Rep State:                    Unknown
    Times Ten Status:
      Daemon:          Down
      Instance:        Unknown
      Release:         Unknown
    Admin User File:   false
    Cache User File:   false
    Cg File:           false
    High Level State:  Down
    Intended State:    Active
    Name:              sample-0
    Schema File:       false
    Cache Status:
      Cache Agent:        Down
      Cache UID Pwd Set:  false
      N Cache Groups:     0
    Db Status:
      Db:            Unknown
      Db Id:         0
      Db Updatable:  Unknown
    Initialized:     true
    Pod Status:
      Agent:                Down
      Last Time Reachable:  0
      Pod IP:
      Pod Phase:            Pending
    Replication Status:
      Last Time Rep State Changed:  0
      Rep Agent:                    Down
      Rep Peer P State:            Unknown
      Rep Scheme:                  Unknown
      Rep State:                   Unknown
    Times Ten Status:
      Daemon:             Down
      Instance:           Unknown
      Release:            Unknown
    Admin User File:      false
    Cache User File:      false
    Cg File:              false
    High Level State:     Unknown
    Intended State:       Standby
    Name:                 sample-1
    Schema File:          false
  Rep Create Statement:  create active standby pair "sample" on
 "sample-0.sample.mynamespace.svc.cluster.local", "sample" on
 "sample-1.sample.mynamespace.svc.cluster.local" NO RETURN store "sample" on
 "sample-0.sample.mynamespace.svc.cluster.local" PORT 4444 FAILTHRESHOLD 0
 store "sample" on "sample-1.sample.mynamespace.svc.cluster.local" PORT 4444
FAILTHRESHOLD  0
  Rep Port:              4444
  Status Version:        1.0
Events:
  Type  Reason  Age   From       Message
  ----  ------  ----  ----       -------
  -     Create  50s   ttclassic  Secret tt517a8646-a354-11ea-a9fb-0a580aed5e4a
created
  -     Create  50s   ttclassic  Service sample created
  -     Create  50s   ttclassic  StatefulSet sample created
```

3. Use the `kubectl get` command again to see if value of the `STATE` field has changed. In this example, the value is `Normal`, indicating the active standby pair of databases are now provisioned and the process is complete.

```
% kubectl get ttc sample
NAME     STATE    ACTIVE     AGE
sample   Normal   sample-0   3m5s
```

4. Use the `kubectl describe` command again to view the active standby pair provisioning in detail.

   Note: In this example, the `now Normal` line displays on its own line. In the actual output, this line does not display as its own line, but at the end of the `StateChange` previous line.

```
% kubectl describe ttc sample
Name:         sample
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>
API Version:  timesten.oracle.com/v4
Kind:         TimesTenClassic
Metadata:
  Creation Timestamp:  2025-01-16T15:35:12Z
  Generation:          1
  Resource Version:    20252668
  Self Link:
/apis/timesten.oracle.com/v4/namespaces/mynamespace/timestenclassics/sample
  UID:                 517a8646-a354-11ea-a9fb-0a580aed5e4a
Spec:
  Ttspec:
    Db Config Map:
      sample
    Image:               container-registry.oracle.com/timesten/timesten:26.1.1.1.0
```

```
      Image Pull Policy:   Always
      Image Pull Secret:   sekret
      Storage Class Name:  oci-bv
      Storage Size:        250Gi
Status:
  Active Pods:       sample-0
  High Level State:  Normal
  Last Event:        35
  Pod Status:
    Cache Status:
      Cache Agent:        Not Running
      Cache UID Pwd Set:  true
      N Cache Groups:     0
    Db Status:
      Db:            Loaded
      Db Id:         26
      Db Updatable:  Yes
    Initialized:     true
    Pod Status:
      Agent:                Up
      Last Time Reachable:  1590939597
      Pod IP:               192.0.2.1
      Pod Phase:            Running
    Replication Status:
      Last Time Rep State Changed:  0
      Rep Agent:                    Running
      Rep Peer P State:             start
      Rep Scheme:                   Exists
      Rep State:                    ACTIVE
    Times Ten Status:
      Daemon:          Up
      Instance:        Exists
      Release:         26.1.1.1.0
    Admin User File:   true
    Cache User File:   false
    Cg File:           false
    High Level State:  Healthy
    Intended State:    Active
    Name:              sample-0
    Schema File:       true
    Cache Status:
      Cache Agent:        Not Running
      Cache UID Pwd Set:  true
      N Cache Groups:     0
    Db Status:
      Db:            Loaded
      Db Id:         26
      Db Updatable:  No
    Initialized:     true
    Pod Status:
      Agent:                Up
      Last Time Reachable:  1590939597
      Pod IP:               192.0.2.2
      Pod Phase:            Running
    Replication Status:
      Last Time Rep State Changed:  1590939496
      Rep Agent:                    Running
      Rep Peer P State:             start
      Rep Scheme:                   Exists
      Rep State:                    STANDBY
    Times Ten Status:
      Daemon:            Up
      Instance:          Exists
      Release:           26.1.1.1.0
    Admin User File:     true
    Cache User File:     false
    Cg File:             false
    High Level State:    Healthy
    Intended State:      Standby
    Name:                sample-1
    Schema File:         true
  Rep Create Statement:  create active standby pair "sample" on
"sample-0.sample.mynamespace.svc.cluster.local", "sample" on
"sample-1.sample.mynamespace.svc.cluster.local" NO RETURN store "sample" on
"sample-0.sample.mynamespace.svc.cluster.local" PORT 4444 FAILTHRESHOLD 0
store "sample" on "sample-1.sample.mynamespace.svc.cluster.local" PORT 4444
FAILTHRESHOLD 0
  Rep Port:              4444
  Status Version:        1.0
Events:
  Type  Reason       Age    From       Message
  ----  ------       ----   ----       -------
  -     Create       4m43s  ttclassic  Secret tt517a8646-a354-11ea-a9fb-0a580aed5e4a
created
  -     Create       4m43s  ttclassic  Service sample created
  -     Create       4m43s  ttclassic  StatefulSet sample created
  -     StateChange  3m47s  ttclassic  Pod sample-0 Daemon Unknown
  -     StateChange  3m47s  ttclassic  Pod sample-0 CacheAgent Unknown
  -     StateChange  3m47s  ttclassic  Pod sample-0 RepAgent Unknown
  -     StateChange  3m47s  ttclassic  Pod sample-1 Daemon Unknown
  -     StateChange  3m47s  ttclassic  Pod sample-1 CacheAgent Unknown
  -     StateChange  3m47s  ttclassic  Pod sample-1 RepAgent Unknown
  -     StateChange  3m26s  ttclassic  Pod sample-0 Agent Up
  -     StateChange  3m26s  ttclassic  Pod sample-0 Release 26.1.1.1.0
  -     StateChange  3m26s  ttclassic  Pod sample-0 Daemon Down
  -     StateChange  3m26s  ttclassic  Pod sample-1 Agent Up
  -     StateChange  3m26s  ttclassic  Pod sample-1 Release 26.1.1.1.0
  -     StateChange  3m26s  ttclassic  Pod sample-1 Daemon Down
  -     StateChange  3m26s  ttclassic  Pod sample-0 Daemon Up
  -     StateChange  3m25s  ttclassic  Pod sample-1 Daemon Up
  -     StateChange  2m13s  ttclassic  Pod sample-0 RepState IDLE
  -     StateChange  2m13s  ttclassic  Pod sample-0 Database Updatable
  -     StateChange  2m13s  ttclassic  Pod sample-0 CacheAgent Not Running
  -     StateChange  2m13s  ttclassic  Pod sample-0 RepAgent Not Running
  -     StateChange  2m13s  ttclassic  Pod sample-0 RepScheme None
  -     StateChange  2m13s  ttclassic  Pod sample-0 Database Loaded
  -     StateChange  2m11s  ttclassic  Pod sample-0 RepAgent Running
  -     StateChange  2m10s  ttclassic  Pod sample-0 RepScheme Exists
  -     StateChange  2m10s  ttclassic  Pod sample-0 RepState ACTIVE
  -     StateChange  113s   ttclassic  Pod sample-1 Database Loaded
  -     StateChange  113s   ttclassic  Pod sample-1 Database Not Updatable
  -     StateChange  113s   ttclassic  Pod sample-1 CacheAgent Not Running
  -     StateChange  113s   ttclassic  Pod sample-1 RepAgent Not Running
  -     StateChange  113s   ttclassic  Pod sample-1 RepScheme Exists
  -     StateChange  113s   ttclassic  Pod sample-1 RepState IDLE
  -     StateChange  106s   ttclassic  Pod sample-1 RepAgent Running
  -     StateChange  101s   ttclassic  Pod sample-1 RepState STANDBY
  -     StateChange  101s   ttclassic  TimesTenClassic was Initializing, now Normal
```

Your active standby pair of TimesTen databases are successfully deployed (as indicated by `Normal`.) There are two TimesTen databases, configured as an active standby pair. One database is active. (In this example, `sample-0` is the active database, as indicated by `Rep State` `ACTIVE`). The other database is standby. (In this example, `sample-1` is the standby database as indicated by `Rep State` `STANDBY`). The active database can be modified and queried. Changes made on the active database are replicated to the standby database. If the active database fails, the Operator automatically promotes the standby database to be the active. The formerly active database will be repaired or replaced, and will then become the standby.

Verify Existence of Underlying Objects

Use the `kubectl describe` commands to verify the underlying objects.

1. StatefulSet:

```
% kubectl get statefulset sample
NAME     READY   AGE
sample   2/2     8m21s
```

2. Service:

```
% kubectl get service sample
NAME     TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)    AGE
sample   ClusterIP   None         <none>        6625/TCP   9m28s
```

3. Pods:

```
% kubectl get pods
NAME                                        READY   STATUS    RESTARTS   AGE
sample-0                                    2/2     Running   0          10m
sample-1                                    2/2     Running   0          10m
timesten-operator-5d7dcc7948-8mnz4          1/1     Running   0          11h
```

4. PersistentVolumeClaims (PVCs):

```
% kubectl get pvc
NAME                             STATUS   VOLUME
CAPACITY   ACCESS MODES   STORAGECLASS   AGE
tt-persistent-sample-0           Bound
ocid1.volume.oc1.phx.abyhqljrbxcgzyixa4pmmcwiqxgqclc7gxvdnoty367w2qn26tij6kfpx
6qq
250Gi        RWO            oci-bv         10m
tt-persistent-sample-1           Bound
ocid1.volume.oc1.phx.abyhqljtt4qxxoj5jqiskriskh66hakaw326rbza4uigmuaezdnu53qhh
oaa
250Gi        RWO            oci-bv         10m
```

Verify Connection to the Active TimesTen Database

You can run the `kubectl exec` command to invoke shells in your Pods and control TimesTen, which is running in those Pods. By default, TimesTen runs in the Pods as the `timesten` user. Once you have established a shell in the Pod, verify you can connect to the `sample` database, and that the information from the metadata files is correct. You can optionally run queries against the database or any other operations.

1. Establish a shell in the Pod.

```
% kubectl exec -it sample-0 -c tt -- /bin/bash
```

2. Connect to the `sample` database. Verify the information in the metadata files is in the database correctly. For example, attempt to connect to the database as the `sampleuser` user. Check that the `PermSize` value of `200` is correct. Check that the `sampleuser.emp` table exists.

```
 % ttIsql sample
```

```
Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
Type ? or "help" for help, type "exit" to quit ttIsql.



connect "DSN=sample";
Connection successful:
DSN=sample;UID=timesten;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;PermSize=200;
DDLReplicationLevel=3;
(Default setting AutoCommit=1)

Command> connect adding "uid=sampleuser;pwd=samplepw" as sampleuser;
Connection successful:
DSN=sample;UID=sampleuser;DataStore=/tt/home/timesten/datastore/sample;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;PermSize=200;
DDLReplicationLevel=3;
(Default setting AutoCommit=1)
sampleuser: Command> tables;
  SAMPLEUSER.EMP
1 table found.
```

Recover from Failure

This example simulates a failure of the active TimesTen database. This is for demonstration purposes only. Do not do this in a production environment.

1. Use the `kubectl delete pod` command to delete the active database (`sample-0` in this case)

   ```
   % kubectl delete pod sample-0
   ```

2. Use the `kubectl describe` command to observe how the Operator recovers from the failure. The Operator promotes the standby database (`sample-1`) to be active. Any applications that were connected to the `sample-0` database are automatically reconnected to the `sample-1` database by TimesTen. After a brief outage, the applications can continue to use the database. See "About the High Level State of TimesTenClassic Objects" for information on the health and states of the active standby pair.

   Note: In this example, the text for the `Message` column displays on two lines for three state changes. However, the actual output displays on one line for each of these three state changes.

   ```
   % kubectl describe ttc sample
   Name:         sample
   ...
   Events:
     Type  Reason       Age    From       Message
     ----  ------       ----   ----       -------
     -     StateChange  2m1s   ttclassic  TimesTenClassic sample: was Normal, now
   ActiveDown
     -     StateChange  115s   ttclassic  Pod sample-1 Database Updatable: Yes
     -     StateChange  115s   ttclassic  TimesTenClassic sample:was ActiveDown, now
   StandbyDown
     -     StateChange  115s   ttclassic  Pod sample-1 RepState ACTIVE
     -     StateChange  110s   ttclassic  Pod sample-0 High Level State Unknown
     -     StateChange  63s    ttclassic  Pod sample-0 Pod Phase Running
     -     StateChange  63s    ttclassic  Pod sample-0 Agent Up
     -     StateChange  63s    ttclassic  Pod sample-0 Instance Exists
     -     StateChange  63s    ttclassic  Pod sample-0 Daemon Up
     -     StateChange  63s    ttclassic  Pod sample-0 Database None
   ```

```
  -     StateChange  42s    ttclassic  Pod sample-0 Database Loaded
  -     StateChange  42s    ttclassic  Pod sample-0 Database Updatable: No
  -     StateChange  42s    ttclassic  Pod sample-0 RepAgent Running
  -     StateChange  42s    ttclassic  Pod sample-0 CacheAgent Not Running
  -     StateChange  42s    ttclassic  Pod sample-0 RepScheme Exists
  -     StateChange  42s    ttclassic  Pod sample-0 RepState IDLE
  -     StateChange  36s    ttclassic  Pod sample-0 High Level State Healthy
  -     StateChange  36s    ttclassic  Pod sample-0 RepState STANDBY
  -     StateChange  36s    ttclassic  TimesTenClassic sample:was StandbyDown, now
Normal
```

Kubernetes has automatically respawned a new `sample-0` Pod to replace the Pod you deleted. The Operator configured TimesTen inside of that Pod, bringing the database in the Pod up as the new standby database. The replicated pair of databases are once again functionally normally.

Clean Up

This example concludes with deleting the databases and all objects associated with TimesTenClassic. These steps are used for example purposes only. Doing these steps results in the termination of the Pods that are running the TimesTen databases as well as the deletion of the TimesTen databases themselves.

1. Delete the ConfigMap object. (`sample`, in this example.)

```
% kubectl delete configmap sample
configmap "sample" deleted
```

2. Delete the TimesTenClassic object and the underlying objects.

```
% kubectl delete -f sample.yaml
timestenclassic.timesten.oracle.com "sample" deleted
```

3. Verify the Pods that were running the TimesTen databases no longer exist.

```
% kubectl get pods
NAME                                      READY   STATUS    RESTARTS   AGE
timesten-operator-5d7dcc7948-8mnz4        1/1     Running   0          5d23h
```

4. Delete the persistent storage used to hold your databases. You have to do this manually.

```
% kubectl get pvc
NAME                     STATUS   VOLUME
CAPACITY   ACCESS MODES   STORAGECLASS   AGE
tt-persistent-sample-0   Bound
...

tt-persistent-sample-1   Bound
...
% kubectl delete pvc tt-persistent-sample-0
persistentvolumeclaim "tt-persistent-sample-0" deleted
% kubectl delete pvc tt-persistent-sample-1
persistentvolumeclaim "tt-persistent-sample-1" deleted
```

5. If you no longer want to run the Operator, you can stop it. Navigate to the `/deploy` directory (*`kube_files`*`/deploy`, in this example) and use the `kubectl delete` command to stop the operator.

```
% cd kube_files/deploy
% kubectl delete -f operator.yaml
deployment.apps "timesten-operator" deleted
```

B

TimesTen Cache in TimesTen Classic Example

This appendix provides a working example for using TimesTen Cache with active standby pair of TimesTen databases in your Kubernetes environment. This example should not be used for production purposes. It assumes a test environment. Your Oracle Database should be customized with the settings specific to your environment.

Topics:

- Set Up the Oracle Database to Cache Data
- Create Metadata Files and a Kubernetes Facility
- Create a TimesTenClassic Object
- Monitor Deployment of a TimesTenClassic Object
- Verify TimesTen Cache Configuration
- Perform Operations On Cache Group Tables
- Clean Up Cache Metadata on the Oracle Database

Set Up the Oracle Database to Cache Data

The following sections describe the tasks that must be performed in the Oracle Database:

- Create the Oracle Database Users
- Grant Privileges to the Cache Administration User
- Create the Oracle Database Tables to Be Cached

Create the Oracle Database Users

Before you can use TimesTen Cache, you must create the following users in your Oracle database:

- A cache administration user. This user creates and maintains Oracle Database objects that store information about the cache environment. This user also enforces predefined behaviors of cache group types.
- One or more schema users who owns Oracle Database tables that are cached in a TimesTen database.

See Create the Oracle Database Users and Default Tablespace in the *Oracle TimesTen In-Memory Database Cache Guide* for information.

This example creates the `cacheuser2` cache administration user and the `oratt` schema user in the Oracle Database.

1. Create a shell from which you can access your Oracle Database and then use SQL*Plus to connect to the Oracle Database as the `sys` user. Then, create a default tablespace to store the TimesTen Cache management objects. See Create the Oracle Database Users and Default Tablespace in the *Oracle TimesTen In-Memory Database Cache Guide* for information.

This example creates the `cachetablespace2` tablespace.

```
% sqlplus sys/syspwd@oracache as sysdba

SQL> CREATE TABLESPACE cachetablespace2 DATAFILE 'datatt2.dbf' SIZE 100M;

Tablespace created.
```

2. Use SQL*Plus to create the schema user. Grant this schema user the minimum privileges required to create tables in the Oracle Database to be cached in your TimesTen database.

   This example creates the `oratt` schema user.

   ```
   SQL> CREATE USER oratt IDENTIFIED BY oraclepwd;

   User created.

   SQL> GRANT CREATE SESSION, RESOURCE TO oratt;

   Grant succeeded.
   ```

3. Use SQL*Plus to create the cache administration user. Assign the `cachetablespace2` tablespace to this user. You will later use the same name of this Oracle cache administration user in the `cacheUser` metadata file.

   This example creates the `cacheuser2` user.

   ```
   SQL> CREATE USER cacheuser2 IDENTIFIED BY oraclepwd
          DEFAULT TABLESPACE cachetablespace2
          QUOTA UNLIMITED ON cachetablespace2;

   User created.

   SQL> commit;

   Commit complete.

   SQL> exit
   ```

Grant Privileges to the Cache Administration User

The cache administration user must be granted a specific set of privileges depending on the cache group types that will be created in the TimesTen databases and the operations performed on those cache groups. TimesTen provides the `grantCacheAdminPrivileges.sql` SQL*Plus script that you can run in your Oracle Database to grant the cache administration user the minimum set of privileges required to perform cache operations. See Grant Privileges to the Oracle Cache Administration User and see Required Privileges for Cache Administration User for Cache Operations in the *Oracle TimesTen In-Memory Database Cache Guide*.

Perform these steps to run the `grantCacheAdminPrivileges.sql` script:

1. Create a shell from which you can access your Oracle Database, and then from the directory of your choice, create an empty subdirectory. This example creates the `oraclescripts` subdirectory.

   ```
   % mkdir -p oraclescripts
   ```

2. From your Linux development host, use the `kubectl cp` command to copy the `grantCacheAdminPrivileges.sql` script from the `*installation_dir*/oraclescripts` directory on your Linux development host to the `oraclescripts` directory that you just created. Recall that the *`installation_dir`* directory was created when you unpacked the TimesTen distribution.

```
% cp /installation_dir/oraclescripts/grantCacheAdminPrivileges.sql
database-oracle:oraclescripts/grantCacheAdminPrivileges.sql
```

3. From your shell, verify the script is located in the `oraclescripts` directory.

```
% ls oraclescripts
grantCacheAdminPrivileges.sql
```

4. Use SQL*Plus to connect to the Oracle Database as the `sys` user. Then, run the *`oraclescripts`*`/grantCacheAdminPrivileges.sql` script. This script grants the `cacheuser2` cache administration user the minimum set of privileges required to perform cache group operations. See Grant Privileges to the Oracle Cache Administration User in the *Oracle TimesTen In-Memory Database Cache Guide*.

```
% sqlplus sys/syspwd@oracache as sysdba

SQL> @grantCacheAdminPrivileges "cacheuser2";

Please enter the administrator user id
The value chosen for administrator user id is cacheuser2

TT_CACHE_ADMIN_ROLE role already exists
***************** Initialization for cache admin begins ******************
0. Granting the CREATE SESSION privilege to CACHEUSER2
1. Granting the TT_CACHE_ADMIN_ROLE to CACHEUSER2
2. Granting the DBMS_LOCK package privilege to CACHEUSER2
3. Granting the DBMS_DDL package privilege to CACHEUSER2
4. Granting the DBMS_FLASHBACK package privilege to CACHEUSER2
5. Granting the CREATE SEQUENCE privilege to CACHEUSER2
6. Granting the CREATE CLUSTER privilege to CACHEUSER2
7. Granting the CREATE OPERATOR privilege to CACHEUSER2
8. Granting the CREATE INDEXTYPE privilege to CACHEUSER2
9. Granting the CREATE TABLE privilege to CACHEUSER2
10. Granting the CREATE PROCEDURE  privilege to CACHEUSER2
11. Granting the CREATE ANY TRIGGER  privilege to CACHEUSER2
12. Granting the GRANT UNLIMITED TABLESPACE privilege to CACHEUSER2
13. Granting the DBMS_LOB package privilege to CACHEUSER2
14. Granting the SELECT on SYS.ALL_OBJECTS privilege to CACHEUSER2
15. Granting the SELECT on SYS.ALL_SYNONYMS privilege to CACHEUSER2
16. Checking if the cache administrator user has permissions on the
    default tablespace
    Permission exists
18. Granting the CREATE TYPE privilege to CACHEUSER2
19. Granting the SELECT on SYS.GV$LOCK privilege to CACHEUSER2
20. Granting the SELECT on SYS.GV$SESSION privilege  to CACHEUSER2
21. Granting the SELECT on SYS.DBA_DATA_FILES privilege  to CACHEUSER2
22. Granting the SELECT on SYS.USER_USERS privilege  to CACHEUSER2
23. Granting the SELECT on SYS.USER_FREE_SPACE privilege  to CACHEUSER2
24. Granting the SELECT on SYS.USER_TS_QUOTAS privilege  to CACHEUSER2
25. Granting the SELECT on SYS.USER_SYS_PRIVS privilege  to CACHEUSER2
26. Granting the SELECT on SYS.V$DATABASE privilege  to CACHEUSER2 (optional)
27. Granting the SELECT ANY TRANSACTION privilege to CACHEUSER2
********* Initialization for cache admin user done successfully *********
```

You have successfully run the `grantCacheAdminPrivileges.sql` script in the Oracle Database.

Create the Oracle Database Tables to Be Cached

This example creates two tables in the `oratt` user schema. See "Create the Oracle Database Users" for information on this user.

- `readtab`: This table will later be cached in a read-only cache group.

- `writetab`: This table will later be cached in an AWT cache group.

1. Create a shell from which you can access your Oracle Database and then use SQL*Plus to connect to the Oracle Database as the `sys` user. Then create the `oratt.readtab` and the `oratt.writetab` tables.

```
% sqlplus sys/syspwd@oracache as sysdba

SQL> CREATE TABLE oratt.readtab (keyval NUMBER NOT NULL PRIMARY KEY,
       str VARCHAR2(32));

Table created.

SQL> CREATE TABLE oratt.writetab (pk NUMBER NOT NULL PRIMARY KEY,
       attr VARCHAR2(40));

Table created.
```

2. Use SQL*Plus to insert rows into the `oratt.readtab` and the `oratt.writetab` tables. Then verify the rows have been inserted.

```
SQL> INSERT INTO oratt.readtab VALUES (1,'Hello');

1 row created.

SQL> INSERT INTO oratt.readtab VALUES (2,'World');

1 row created.

SQL> INSERT INTO oratt.writetab VALUES (100, 'TimesTen');

1 row created.

SQL> INSERT INTO oratt.writetab VALUES (101, 'Cache');

1 row created.

SQL> commit;

Commit complete.
```

Verify the rows have been inserted into the tables.

```
SQL> SELECT * FROM oratt.readtab;

    KEYVAL STR
---------- --------------------------------
         1 Hello
         2 World

SQL>  SELECT * FROM oratt.writetab;

        PK ATTR
---------- ----------------------------------------
       100 TimesTen
       101 Cache
```

3. Use SQL*Plus to grant the `SELECT` privilege on the `oratt.readtab` table and the `SELECT`, `INSERT`, `UPDATE`, and `DELETE` privileges on the `oratt.writetab` table to the cache administration user (`cacheuser2`, in this example).

```
SQL> GRANT SELECT ON oratt.readtab TO cacheuser2;

Grant succeeded.
```

```
SQL> GRANT SELECT ON oratt.writetab TO cacheuser2;

Grant succeeded.

SQL> GRANT INSERT ON oratt.writetab TO cacheuser2;

Grant succeeded.

SQL> GRANT UPDATE ON oratt.writetab TO cacheuser2;

Grant succeeded.

SQL> GRANT DELETE ON oratt.writetab TO cacheuser2;

Grant succeeded.
```

4. Use SQL*Plus to query the `nls_database_parameters` system view to determine the Oracle Database database character set. The Oracle Database database character set must match the TimesTen database character set. (The TimesTen database character set will be set later. See "Create Metadata Files and a Kubernetes Facility" for details.)

   In this example, the query returns the `AL32UTF8` database character set.

   ```
   SQL> SELECT value FROM nls_database_parameters WHERE
          parameter='NLS_CHARACTERSET';

   VALUE
   ------------------------------------------------------------------------------
   AL32UTF8
   ```

You have successfully created the Oracle Database tables that will be cached in the TimesTen cache group tables.

Create Metadata Files and a Kubernetes Facility

There are metadata files that are specific to using TimesTen Cache:

- `cacheUser`: This file is required. The user in this file is created in the TimesTen databases and serves as the cache manager. The name of this user must match the name of the cache administration user that you created in the Oracle Database. See "Create the Oracle Database Users" for information on the cache administration user in the Oracle Database. Also see "cacheUser" for more information on the `cacheUser` metadata file.
- `cachegroups.sql`: This file is required. The contents of this file contain the `CREATE CACHE GROUP` definitions. The file can also contain the `LOAD CACHE GROUP` statement and the built-in procedures to update statistics on the cache group tables (such as, `ttOptEstimateStats` and `ttOptUpdateStats`). See "cachegroups.sql" for more information on this file.
- `tnsnames.ora`: This file is required. It defines Oracle Net Services to which applications connect. For TimesTen Cache, this file configures the connectivity between TimesTen and the Oracle Database (from which data is being cached). In this context, TimesTen is the application that is the connection to the Oracle Database. See "tnsnames.ora" for more information on this file.
- `sqlnet.ora`: This file may be required. It may be necessary depending on your Oracle Database configuration. The file defines options for how client applications communicate with the Oracle Database. In this context, TimesTen is the application. The `tnsnames.ora` and `sqlnet.ora` files together define how an application communicates with the Oracle Database. See "sqlnet.ora" for information on this file.

- `db.ini`: This file is required if you are using TimesTen Cache. The contents of this file contain TimesTen connection attributes for your TimesTen databases, which will be included in TimesTen's `sys.odbc.ini` file. For TimesTen Cache, you must specify the `OracleNetServiceName` and the `DatabaseCharacterSet` connection attributes. The `DatabaseCharacterSet` connection attribute must match the Oracle database character set. See "db.ini" for more information on this file.
- `schema.sql`: The contents of this file contain database objects, such as tables, sequences, and users. The instance administrator uses the `ttIsql` utility to run this file immediately after the database is created. This file is run before the Operator configures TimesTen Cache or replication, so ensure there are no cache definitions in this file.

  In TimesTen Cache, one or more cache table users own the cache tables. If this cache table user is not the cache manager user, then you must specify the `schema.sql` file and in it you must include the schema user and assign the appropriate privileges to this schema user. For example, if the `oratt` schema user was created in the Oracle Database, and this user is not the TimesTen cache manager user, you must create the TimesTen `oratt` user in this file. See "Create the Oracle Database Users" for more information on the schema users in the Oracle Database. Also see "schema.sql" for more information on the `schema.sql` file.

In addition, you can use these other supported metadata files:

- `adminUser`: The user in this file is created in the TimesTen databases and is granted `ADMIN` privileges. See "adminUser" for more information on this file.
- `epilog.sql`: The contents of this file contain operations that must be performed after the Operator configures replication. For example, if you are using XLA, you could create replicated bookmarks for XLA in this file. This file is run after cache and replication have been configured. See "epilog.sql" for more information on this file.

You can include these metadata files in one or more Kubernetes facilities (for example, in a Kubernetes Secret, in a ConfigMap, or in an init container). This ensures the metadata files are populated in the `/ttconfig` directory of the TimesTen containers. Note that there is no requirement as to how to get the metadata files into this `/ttconfig` directory. See "Populate the /ttconfig Directory" for more information.

This example uses the ConfigMap facility to populate the `/ttconfig` directory in your TimesTen containers. The `adminUser`, `db.ini`, `schema.sql`, `cacheUser`, `cachegroups.sql`, `tnsnames.ora`, and `sqlnet.ora` metadata files are used in this example.

On your Linux development host:

1. From the directory of your choice, create an empty subdirectory for the metadata files. This example creates the `cm_cachetest` subdirectory. (The `cm_cachetest` directory is used in the remainder of this example to denote this directory.)

   ```
   % mkdir -p cm_cachetest
   ```

2. Navigate to the ConfigMap directory.

   ```
   % cd cm_cachetest
   ```

3. Create the `adminUser` file in this ConfigMap directory (`cm_cachetest`, in this example). In this `adminUser` file, create the `sampleuser` user with the `samplepw` password.

   ```
   vi adminUser

   sampleuser/samplepw
   ```

4. Create the `db.ini` file in this ConfigMap directory (`cm_cachetest`, in this example). In this `db.ini` file, define the `PermSize`, `DatabaseCharacterSet`, and the `OracleNetServiceName`

connection attributes. The `DatabaseCharacterSet` value must match the database character set value in the Oracle Database. See "Create the Oracle Database Tables to Be Cached" for information on how to query the `nls_database_parameters` system view to determine the Oracle Database database character set. In this example, the value is `AL32UTF8`.

```
vi db.ini

PermSize=200
DatabaseCharacterSet=AL32UTF8
OracleNetServiceName=Oracache
```

5. Create the `schema.sql` file in this ConfigMap directory (`cm_cachetest`, in this example). In this example, create the `oratt` user. Recall that this user was previously created in the Oracle Database. See "Create the Oracle Database Users" for information on the `oratt` user in the Oracle Database.

   ```
   vi schema.sql

   create user oratt identified by ttpwd;
   grant admin to oratt;
   ```

6. Create the `cacheUser` metadata file in this ConfigMap directory (`cm_cachetest`, in this example). The `cacheUser` file must contain one line of the form `cacheuser/ttpassword/orapassword`, where `cacheuser` is the user you wish to designate as the cache manager in the TimesTen database, `ttpassword` is the TimesTen password you wish to assign to this user, and `orapassword` is the Oracle Database password that has already been assigned to the Oracle Database cache administration user. Note that the `cacheUser` name in this file must match the Oracle Database cache administration user that you previously created. See "Create the Oracle Database Users" for more information on the Oracle Database cache administration user.

   In this example, the `cacheuser2` user with password of `oraclepwd` was already created in the Oracle Database. Therefore, supply `cacheuser2` as the TimesTen cache manager user. You can assign any TimesTen password to this TimesTen cache manager user. This example assigns `ttpwd`.

   ```
   vi cacheuser

   cacheuser2/ttpwd/oraclepwd
   ```

7. Create the `cachegroups.sql` metadata file in this ConfigMap directory (`cm_cachetest`, in this example). The `cachegroups.sql` file contains the cache group definitions. In this example, a dynamic AWT cache group and a read-only cache group are created. In addition, the `LOAD CACHE GROUP` statement is included to load rows from the `oratt.readtab` cached table in the Oracle Database into the `oratt.readtab` cache table in the TimesTen database.

   ```
   vi cachegroups.sql

   CREATE DYNAMIC ASYNCHRONOUS WRITETHROUGH CACHE GROUP writecache
   FROM oratt.writetab (pk NUMBER NOT NULL PRIMARY KEY,attr VARCHAR2(40));

   CREATE READONLY CACHE GROUP readcache
   AUTOREFRESH
     INTERVAL 5 SECONDS
   FROM oratt.readtab (keyval NUMBER NOT NULL PRIMARY KEY,str VARCHAR2(32));

   LOAD CACHE GROUP readcache COMMIT EVERY 256 ROWS;
   ```

8. Create the `tnsnames.ora` metadata file in this ConfigMap directory (`cm_cachetest`, in this example).

```
vi tnsnames.ora

OraTest =
 (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = database.myhost.svc.cluster.local)
     (PORT = 1521))
   (CONNECT_DATA =
     (SERVER = DEDICATED)
     (SERVICE_NAME = OraTest.my.sample.com)))
OraCache =
 (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = database.myhost.svc.cluster.local)
     (PORT = 1521))
   (CONNECT_DATA =
     (SERVER = DEDICATED)
     (SERVICE_NAME = OraCache.my.sample.com)))
```

9. Create the `sqlnet.ora` metadata file in this ConfigMap directory (`cm_cachetest`, in this example).

```
vi sqlnet.ora

NAME.DIRECTORY_PATH= {TNSNAMES, EZCONNECT, HOSTNAME}
SQLNET.EXPIRE_TIME = 10
SSL_VERSION = 1.2
```

10. Use the Linux `ls` command to verify the metadata files are in the ConfigMap directory (`cm_cachetest`, in this example).

```
% ls
adminUser        cacheUser  schema.sql  tnsnames.ora
cachegroups.sql  db.ini     sqlnet.ora
```

11. Create the ConfigMap. The files in the `cm_cachetest` directory are included in the ConfigMap and, later, will be available in the TimesTen containers.

    In this example:

    - The name of the ConfigMap is `cachetest`. Replace `cachetest` with a name of your choosing. (`cachetest` is represented in **bold** in this example.)
    - This example uses `cm_cachetest` as the directory where the files that will be copied into the ConfigMap reside. If you use a different directory, replace `cm_cachetest` with the name of your directory. (`cm_cachetest` is represented in **bold** in this example.)

    Use the `kubectl create` command to create the ConfigMap:

```
% kubectl create configmap cachetest --from-file=cm_cachetest
configmap/cachetest created
```

12. Use the `kubectl describe` command to verify the contents of the ConfigMap. (`cachetest`, in this example.) The metadata files are represented in **bold**.

```
% kubectl describe configmap cachetest;
Name:         cachetest
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>

Data
====
tnsnames.ora:
----

OraTest =
 (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = database.myhost.svc.cluster.local)
     (PORT = 1521))
   (CONNECT_DATA =
     (SERVER = DEDICATED)
     (SERVICE_NAME = OraTest.my.sample.com)))
OraCache =
 (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = database.myhost.svc.cluster.local)
     (PORT = 1521))
   (CONNECT_DATA =
     (SERVER = DEDICATED)
     (SERVICE_NAME = OraCache.my.sample.com)))

adminUser:
----
sampleuser/samplepw

cacheUser:
----
cacheuser2/ttpwd/oraclepwd

cachegroups.sql:
----
CREATE DYNAMIC ASYNCHRONOUS WRITETHROUGH CACHE GROUP writecache
FROM oratt.writetab (
  pk NUMBER NOT NULL PRIMARY KEY,
  attr VARCHAR2(40)
);

CREATE READONLY CACHE GROUP readcache
AUTOREFRESH
  INTERVAL 5 SECONDS
FROM oratt.readtab (
  keyval NUMBER NOT NULL PRIMARY KEY,
  str VARCHAR2(32)
);

LOAD CACHE GROUP readcache COMMIT EVERY 256 ROWS;

db.ini:
----
permSize=200
databaseCharacterSet=AL32UTF8
oracleNetServiceName=Oracache

schema.sql:
----
create user oratt identified by ttpwd;
grant admin to oratt;

sqlnet.ora:
----
NAME.DIRECTORY_PATH= {TNSNAMES, EZCONNECT, HOSTNAME}
SQLNET.EXPIRE_TIME = 10
SSL_VERSION = 1.2


Events:  <none>
```

You have successfully created and deployed the `cachetest` ConfigMap.

Create a TimesTenClassic Object

This section creates a TimesTenClassic object.

Perform these steps:

1. Create an empty YAML file. You can choose any name, but you may want to use the same name you used for the name of the TimesTenClassic object. (In this example, `cachetest`.) The YAML file contains the definitions for the TimesTenClassic object. See TimesTenClassicSpecSpec for information on the fields that you must specify in this YAML file as well as the fields that are optional.

   In this example, note these fields:

   - `name`: Replace `cachetest` with the name of your TimesTenClassic object (represented in **bold**).
   - `storageClassName`: Replace `oci-bv` with the name of the storage class used to allocate PersistentVolumes to hold TimesTen.
   - `storageSize`: Replace `250Gi` with the amount of storage that should be requested for each Pod to hold TimesTen. Note: This example assumes a production environment and uses a value of `250Gi` for `storageSize`. For demonstration purposes, a value of `50Gi` is adequate.
   - `image`: Replace `container-registry.oracle.com/timesten/timesten:26.1.1.1.0` with the location and name of your image.
   - `imagePullSecret`: Replace `sekret` with the image pull secret that Kubernetes should use to fetch the TimesTen image.
   - `dbConfigMap`: This example uses one ConfigMap (called `cachetest`) for the metadata files (represented in **bold**).

   ```
   % vi cachetest.yaml

   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   metadata:
     name: cachetest
   spec:
     ttspec:
       storageClassName: oci-bv
       storageSize: 250Gi
       image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
       imagePullSecret: sekret
       dbConfigMap:
       - cachetest
   ```

2. Use the `kubectl create` command to create the TimesTenClassic object from the contents of the YAML file (in this example, `cachetest.yaml`). Doing so begins the process of deploying your active standby pair of TimesTen databases in the Kubernetes cluster.

   ```
   % kubectl create -f cachetest.yaml
   timestenclassic.timesten.oracle.com/cachetest created
   ```

You have successfully created the TimesTenClassic object in the Kubernetes cluster. The process of deploying your TimesTen databases begins, but is not yet complete.

Monitor Deployment of a TimesTenClassic Object

Use the `kubectl get` and the `kubectl describe` commands to monitor the progress of the active standby pair as it is provisioned.

1. Use the `kubectl get` command and review the `STATE` field. Observe the value is `Initializing`. The active standby pair provisioning has begun, but is not yet complete.

```
% kubectl get ttc cachetest
NAME        STATE          ACTIVE   AGE
cachetest   Initializing   None     41s
```

2. Use the `kubectl get` command again to see if value of the `STATE` field has changed. In this example, the value is `Normal`, indicating the active standby pair of databases are now provisioned and the process is complete.

```
% kubectl get ttc cachetest
NAME        STATE    ACTIVE        AGE
cachetest   Normal   cachetest-0   3m58s
```

3. Use the `kubectl describe` command to view the active standby pair provisioning in detail.

   Note the following:

   - The `cachetest` Configmap has been correctly referenced in the `dbConfigMap` field (represented in **bold**).
   - The cache agent is running in the active and the standby Pods (represented in **bold**).
   - The cache administration user UID and password have been set in the active and the standby Pods (represented in **bold**).
   - Two cache groups have been created in the active and the standby Pods (represented in **bold**).
   - The replication agent is running in the active and standby Pods (represented in **bold**).

```
% kubectl describe ttc cachetest
Name:         cachetest
Namespace:    mynamespace
Labels:       <none>
Annotations:  <none>
API Version:  timesten.oracle.com/v4
Kind:         TimesTenClassic
Metadata:
  Creation Timestamp:  2025-01-16T03:29:48Z
  Generation:          1
  Resource Version:    78390500
  Self Link:           /apis/timesten.oracle.com/v4/namespaces/mynamespace/
timestenclassics/cachetest
  UID:                 2b18d81d-15a9-11eb-b999-be712d29a81e
Spec:
  Ttspec:
    Db Config Map:
      cachetest
    Image:               container-registry.oracle.com/timesten/timesten:26.1.1.1.0
    Image Pull Policy:   Always
    Image Pull Secret:   sekret
    Storage Class Name:  oci-bv
    Storage Size:        250Gi
Status:
  Active Pods:       cachetest-0
  High Level State:  Normal
```

```
Last Event:       28
Pod Status:
  Cache Status:
    Cache Agent:        Running
    Cache UID Pwd Set:  true
    N Cache Groups:     2
  Db Status:
    Db:           Loaded
    Db Id:        30
    Db Updatable:  Yes
  Initialized:     true
  Pod Status:
    Agent:                Up
    Last Time Reachable:  1603510527
    Pod IP:               10.244.7.92
    Pod Phase:            Running
  Replication Status:
    Last Time Rep State Changed:  0
    Rep Agent:                    Running
    Rep Peer P State:             start
    Rep Scheme:                   Exists
    Rep State:                    ACTIVE
  Times Ten Status:
    Daemon:          Up
    Instance:        Exists
    Release:         26.1.1.1.0
  Admin User File:   true
  Cache User File:   true
  Cg File:           true
  High Level State:  Healthy
  Intended State:    Active
  Name:              cachetest-0
  Schema File:       true
  Cache Status:
    Cache Agent:        Running
    Cache UID Pwd Set:  true
    N Cache Groups:     2
  Db Status:
    Db:           Loaded
    Db Id:        30
    Db Updatable:  No
  Initialized:     true
  Pod Status:
    Agent:                Up
    Last Time Reachable:  1603510527
    Pod IP:               10.244.8.170
    Pod Phase:            Running
  Replication Status:
    Last Time Rep State Changed:  1603510411
    Rep Agent:                    Running
    Rep Peer P State:             start
    Rep Scheme:                   Exists
    Rep State:                    STANDBY
  Times Ten Status:
    Daemon:            Up
    Instance:          Exists
    Release:           26.1.1.1.0
  Admin User File:     true
  Cache User File:     true
  Cg File:             true
  High Level State:    Healthy
  Intended State:      Standby
```

```
    Name:                cachetest-1
    Schema File:         true
  Rep Create Statement:  create active standby pair "cachetest" on
  "cachetest-0.cachetest.mynamespace.svc.cluster.local", "cachetest" on
  "cachetest-1.cachetest.mynamespace.svc.cluster.local" NO RETURN store
  "cachetest" on "cachetest-0.cachetest.mynamespace.svc.cluster.local"
  PORT 4444 FAILTHRESHOLD 0 store "cachetest" on
 "cachetest-1.cachetest.mynamespace.svc.cluster.local" PORT 4444 FAILTHRESHOLD 0
  Rep Port:              4444
  Status Version:        1.0
Events:
  Type  Reason       Age    From       Message
  ----  ------       ----   ----       -------
  -     Create       5m40s  ttclassic  Secret tt2b18d81d-15a9-11eb-b999-be712d29a81e
created
  -     Create       5m40s  ttclassic  Service cachetest created
  -     Create       5m40s  ttclassic  StatefulSet cachetest created
  -     StateChange  4m28s  ttclassic  Pod cachetest-0 Agent Up
  -     StateChange  4m28s  ttclassic  Pod cachetest-0 Release 26.1.1.1.0
  -     StateChange  4m28s  ttclassic  Pod cachetest-0 Daemon Up
  -     StateChange  3m18s  ttclassic  Pod cachetest-0 RepScheme None
  -     StateChange  3m18s  ttclassic  Pod cachetest-0 RepAgent Not Running
  -     StateChange  3m18s  ttclassic  Pod cachetest-0 RepState IDLE
  -     StateChange  3m18s  ttclassic  Pod cachetest-0 Database Loaded
  -     StateChange  3m18s  ttclassic  Pod cachetest-0 Database Updatable
  -     StateChange  3m18s  ttclassic  Pod cachetest-0 CacheAgent Not Running
  -     StateChange  2m57s  ttclassic  Pod cachetest-0 CacheAgent Running
  -     StateChange  2m47s  ttclassic  Pod cachetest-1 Agent Up
  -     StateChange  2m47s  ttclassic  Pod cachetest-1 Release 26.1.1.1.0
  -     StateChange  2m46s  ttclassic  Pod cachetest-0 RepAgent Running
  -     StateChange  2m46s  ttclassic  Pod cachetest-0 RepScheme Exists
  -     StateChange  2m46s  ttclassic  Pod cachetest-0 RepState ACTIVE
  -     StateChange  2m46s  ttclassic  Pod cachetest-1 Daemon Up
  -     StateChange  2m9s   ttclassic  Pod cachetest-1 CacheAgent Running
  -     StateChange  2m9s   ttclassic  Pod cachetest-1 Database Not Updatable
  -     StateChange  2m9s   ttclassic  Pod cachetest-1 Database Loaded
  -     StateChange  2m9s   ttclassic  Pod cachetest-1 RepAgent Not Running
  -     StateChange  2m9s   ttclassic  Pod cachetest-1 RepScheme Exists
  -     StateChange  2m9s   ttclassic  Pod cachetest-1 RepState IDLE
  -     StateChange  2m3s   ttclassic  Pod cachetest-1 RepAgent Running
  -     StateChange  118s   ttclassic  Pod cachetest-1 RepState STANDBY
  -     StateChange  118s   ttclassic  TimesTenClassic was Initializing, now Normal
```

Your active standby pair of TimesTen databases are successfully deployed (as indicated by `Normal`.) You are now ready to verify that TimesTen Cache is configured correctly and is working properly.

Verify TimesTen Cache Configuration

To verify that TimesTen Cache is configured correctly and is working properly, perform the following steps:

1. Review the active (`cachetest-0`, in this example) Pod and the standby Pod (`cachetest-1`, in this example).

```
% kubectl get pods
NAME                                   READY   STATUS    RESTARTS   AGE
cachetest-0                            2/2     Running   0          8m16s
cachetest-1                            2/2     Running   0          8m15s
timesten-operator-f84766548-tch7s      1/1     Running   0          36d
```

2. Use the `kubectl exec -it` command to invoke the shell in the active Pod (`cachetest-0`, in this example).

   ```
   % kubectl exec -it cachetest-0 -c tt -- /bin/bash
   ```

3. Use `ttIsql` to connect to the `cachetest` database. Confirm the TimesTen connection attributes are correct. In particular, note that the `OracleNetServiceName` connection attribute is correctly set to `Oracache` (represented in **bold**).

   ```
   % ttIsql cachetest;

   Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
   Type ? or "help" for help, type "exit" to quit ttIsql.



   connect "DSN=cachetest";
   Connection successful: DSN=cachetest;UID=timesten;DataStore=/tt/home/timesten/
   datastore/cachetest;
   DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;AutoCreate=0;
   PermSize=200;OracleNetServiceName=Oracache;DDLReplicationLevel=3;
   ForceDisconnectEnabled=1;
   (Default setting AutoCommit=1)
   ```

4. Use the `ttIsql cachegroups` to view the definition of the `cacheuser2.readcache` and the `cacheuser2.writecache` cache groups.

   ```
   Command> cachegroups;

   Cache Group CACHEUSER2.READCACHE:

     Cache Group Type: Read Only
     Autorefresh: Yes
     Autorefresh Mode: Incremental
     Autorefresh State: On
     Autorefresh Interval: 5 Seconds
     Autorefresh Status: ok
     Aging: No aging defined

     Root Table: ORATT.READTAB
     Table Type: Read Only

   Cache Group CACHEUSER2.WRITECACHE:

     Cache Group Type: Asynchronous Writethrough (Dynamic)
     Autorefresh: No
     Aging: LRU on

     Root Table: ORATT.WRITETAB
     Table Type: Propagate

   2 cache groups found.
   ```

5. Use `ttIsql` to query the `oratt.readtab` cache table. Note that the data from the `oratt.readtab` cached table in the Oracle Database is correctly loaded in the `oratt.readcache` cache table in the TimesTen database. Recall that you specified the `LOAD CACHE GROUP` statement in the `cachegroups.sql` metadata file. See Create Metadata Files and a Kubernetes Facility for information on this `cachegroups.sql` metadata file.

   ```
   Command> SELECT * FROM oratt.readtab;
   < 1, Hello >
   < 2, World >
   2 rows found.
   ```

You have verified that the cache groups were created and data was correctly loaded in the `oratt.readtab` table.

Perform Operations On Cache Group Tables

The examples in this section perform operations on the `oratt.readtab` and the `oratt.writetab` tables to verify that TimesTen Cache is working properly.

- Perform Operations on the oratt.readtab Table
- Perform Operations on the oratt.writetab Table

Perform Operations on the oratt.readtab Table

This section performs operations on the `oratt.readtab` table.

1. Create a shell from which you can access your Oracle Database and then use SQL*Plus to connect to the Oracle Database as the schema user (`oratt`, in this example). Then, insert a new row, delete an existing row, and update an existing row in the `oratt.readtab` table of the Oracle Database and commit the changes.

   ```
   % sqlplus oratt/oraclepwd@oracache;

   SQL> INSERT INTO oratt.readtab VALUES (3,'Welcome');

   1 row created.

   SQL> DELETE FROM oratt.readtab WHERE keyval=2;

   1 row deleted.

   SQL> UPDATE oratt.readtab SET str='Hi' WHERE keyval=1;

   1 row updated.

   SQL> COMMIT;

   Commit complete.
   ```

   Since the read-only cache group was created with an autorefresh interval of 5 seconds, the TimesTen `oratt.readtab` cache table in the `readcache` cache group is automatically refreshed after 5 seconds with the committed updates from the cached `oratt.readtab` table of the Oracle Database. The next step is to test that the data was correctly propagated from the Oracle Database to the TimesTen database.

2. Use the `kubectl exec -it` command to invoke the shell in the container of the Pod that is running the TimesTen active database (`cachetest-0`, in this example).

   ```
   % kubectl exec -it cachetest-0 -c tt -- /bin/bash
   ```

3. Use the TimesTen `ttIsql` utility to connect to the `cachetest` database. Query the TimesTen `oratt.readtab` table to verify that the table has been updated with the committed updates from the Oracle Database.

   ```
   % ttIsql cachetest;

   Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
   Type ? or "help" for help, type "exit" to quit ttIsql.
   ```

```
connect "DSN=cachetest";
Connection successful: DSN=cachetest;UID=timesten;DataStore=/tt/home/timesten/
datastore/cachetest;
DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;AutoCreate=0;
PermSize=200;OracleNetServiceName=Oracache;DDLReplicationLevel=3;
ForceDisconnectEnabled=1;
(Default setting AutoCommit=1)

Command> SELECT * FROM oratt.readtab;
< 1, Hi >
< 3, Welcome >
2 rows found.
```

You have verified that TimesTen Cache is working correctly for the `oratt.readtab` table and the `readcache` cachegroup.

Perform Operations on the oratt.writetab Table

This example performs operations on the `oratt.writetab` table.

1. Use the `kubectl exec -it` command to invoke the shell in the container of the Pod that is running the TimesTen active database (`cachetest-0`, in this example).

   ```
   % kubectl exec -it cachetest-0 -c tt -- /bin/bash
   ```

2. Use the TimesTen `ttIsql` utility to connect to the `cachetest` database as the cache manager user (`cacheuser2`, in this example). Issue a `SELECT` statement on the TimesTen `oratt.writetab` table. Recall that the `writecache` cache group is a dynamic cache group. Thus by issuing the `SELECT` statement, the cache instance is automatically loaded from the cached Oracle Database table, if the data is not found in the TimeTen cache table.

   ```
   % ttIsql "DSN=cachetest;UID=cacheuser2;PWD=ttpwd;OraclePWD=oraclepwd";

   Copyright (c) 1996, 2025, Oracle and/or its affiliates. All rights reserved.
   Type ? or "help" for help, type "exit" to quit ttIsql.



   connect "DSN=cachetest;UID=cacheuser2;PWD=********;OraclePWD=********";
   Connection successful: DSN=cachetest;UID=cacheuser2;DataStore=/tt/home/timesten/
   datastore/cachetest;
   DatabaseCharacterSet=AL32UTF8;ConnectionCharacterSet=AL32UTF8;AutoCreate=0;
   PermSize=200;OracleNetServiceName=Oracache;DDLReplicationLevel=3;
   ForceDisconnectEnabled=1;
   (Default setting AutoCommit=1)

   Command> SELECT * FROM oratt.writetab WHERE pk=100;
   < 100, TimesTen >
   1 row found.
   ```

3. Use `ttIsql` to insert a new row, delete an existing row, and update an existing row in the TimesTen `oratt.writetab` cache table, and commit the changes.

   ```
   Command> INSERT INTO oratt.writetab VALUES (102,'Cache');
   1 row inserted.
   Command> DELETE FROM oratt.writetab WHERE pk=101;
   1 row deleted.
   Command> UPDATE oratt.writetab SET attr='Oracle' WHERE pk=100;
   1 row updated.
   Command> COMMIT;
   ```

The committed updates on the TimesTen `oratt.writetab` cache table in the `writecache` cache group should automatically be propagated to the `oratt.writetab` table in the Oracle Database.

4. Create a shell from which you can access your Oracle Database and then use SQL*Plus to connect to the Oracle database as the schema user (`oratt`, in this example). Then query the contents of the `oratt.writetab` table in the Oracle Database to verify the committed updates from the TimesTen database have been propagated to the `oratt.writetab` table of the Oracle Database.

```
% sqlplus oratt/oraclepwd@orapcache;

SQL> SELECT * FROM oratt.writetab ORDER BY pk;

        PK ATTR
---------- ----------------------------------------
       100 Oracle
       102 Cache
```

You have verified that TimesTen Cache is working correctly for the `oratt.writetab` table and the `writecache` cachegroup.

Clean Up Cache Metadata on the Oracle Database

When you create certain types of cache groups in a TimesTen database, TimesTen stores metadata about that cache group in the Oracle Database. If you later delete that TimesTen database, TimesTen does not automatically delete the metadata in the Oracle Database. As a result, metadata can accumulate on the Oracle Database. See Dropping Oracle Database Objects Used by Cache Groups with Autorefresh in the *Oracle TimesTen In-Memory Database Cache Guide* for more information.

However, in a Kubernetes environment, if you provide a `cacheUser` metadata file and a `cachegroups.sql` metadata file when you initially create the TimesTenClassic object, then, by default, the Operator automatically cleans up the Oracle Database metadata if you delete that TimesTenClassic object.

If you do not want the Operator to automatically clean up the Oracle Database, you set the `cacheCleanup` field in the TimesTenClassic object definition to `false`. See the `cacheCleanup` entry in "Table 18-3" for more information. Also see "About Configuration Metadata Details" for information on the `cacheUser` and the `cachegroups.sql` files.

C

Create Your Own Oracle Wallet, Certificates, and Secrets for Exposing TimesTen Metrics

By default, the TimesTen Operator automatically exposes TimesTen metrics and uses Transport Layer Security (mutual TLS)/https to serve these metrics. It exposes these metrics to Prometheus or any other scrape target.

The TimesTen Operator works with the TimesTen exporter to expose these metrics. For more information about the TimesTen exporter, see Overview of the TimesTen Kubernetes Operator and the TimesTen Exporter.

If TimesTen metrics are served by https, then by default the TimesTen Operator automatically creates an Oracle Wallet, all necessary certificates, and Kubernetes Secrets so that https can be used to expose TimesTen metrics securely.

For more information about how the TimesTen Operator exposes TimesTen metrics, see Expose TimesTen Metrics with the TimesTen Kubernetes Operator.

Although not recommended, you have the option of creating your own Oracle Wallet, certificates, and Kubernetes Secrets for use in exporting these metrics.

This appendix shows you how.

Topics:

- About Creating Your Own Oracle Wallet, Certificates, and Kubernetes Secrets
- Create Your Own Oracle Wallet, Certificates, and Kubernetes Secrets

About Creating Your Own Oracle Wallet, Certificates, and Kubernetes Secrets

You have the option of creating your own Oracle Wallet, certificates, and Kubernetes Secrets to serve TimesTen metrics by https. If you choose this option, the TimesTen Operator cannot create a PodMonitor object with sufficient information to allow Prometheus to access TimesTen. You can create a PodMonitor object yourself or otherwise edit the Prometheus configuration files to cause Prometheus to scrape TimesTen metrics.

After you create a Kubernetes Secret containing an Oracle Wallet (that contains the necessary certificates), you must include this Secret in your TimesTenClassic or TimesTenClassic object YAML manifest file. You do this by specifying the `.spec.ttspec.prometheus.certSecret` datum in your object definition.

Here is a code snippet of a TimesTenClassic object YAML manifest file:

```
apiVersion: timesten.oracle.com/v4
kind: TimesTenClassic
metadata:
  name: samplecertsecret
spec:
  ttspec:
```

```
...
    prometheus:
      certSecret: prometheuscert
      port: 7777
```

Note the following:

- The `.spec.ttspec.prometheus` datum is specified in the TimesTen Classic object YAML manifest file. This causes the TimesTen Operator to automatically deploy the TimesTen exporter in a separate container within each Pod running TimesTen.
- The `certSecret` datum is specified in the `.spec.ttspec.prometheus` clause of the TimesTenClassic object. The wallet contained in the `prometheusecert` Kubernetes Secret is used for Transport Layer Security (mutual TLS)/https.

  The `port` datum is specified. This is the port on which the TimesTen exporter listens. The causes the TimesTen Operator to set up the http server on TCP port 7777 in each TimesTen Pod.

Here is a summary of the tasks you need to complete to create your own Oracle Wallet, certificates, and Kubernetes Secret. The summary also includes the tasks to include the appropriate Kubernetes Secret in a TimesTenClassic object YAML manifest file. There is a complete example in Create Your Own Oracle Wallet, Certificates, and Kubernetes Secrets.

- Create a TimesTen instance. See Before You Begin.
- Use the TimesTen `ttExporter` utility to generate the certificates. One of the certificates that is created is the self-signed server certificate. This certificate is placed in an Oracle Wallet. See Create Certificates.
- Place the Oracle Wallet into a Kubernetes Secret. See Create a Kubernetes Secret Containing an Oracle Wallet.
- Specify the name of the Secret in the `spec.ttspec.prometheus.certSecret` datum of a TimesTenClassic object YAML manifest file. See Define and Deploy a TimesTenClassic Object.
- Save the PEM formatted file containing the server certificate, the client certificate, and the client private key that were created when you ran the TimesTen `ttExporter` utility. You need these later to configure the Prometheus server. See Create Certificates.

Here are additional references:

- For information about the `spec.ttspec.prometheus.certSecret` datum, see TimesTenClassicSpecSpecPrometheus.
- For information about the command line options for the `ttExporter` utility, see ttExporter in the *Oracle TimesTen In-Memory Database Reference*.

Create Your Own Oracle Wallet, Certificates, and Kubernetes Secrets

Let's look at an example that shows you how to create your own Oracle Wallet, certificates, and Kubernetes Secrets. The example also shows you how to specify a Kubernetes Secret that contains an Oracle Wallet in a TimesTenClassic object YAML manifest file.

- Before You Begin
- Create Certificates

- Create a Kubernetes Secret Containing an Oracle Wallet
- Define and Deploy a TimesTenClassic Object

Before You Begin

The TimesTen `ttExporter` utility is located in the `/bin` directory of a TimesTen instance. Since the `ttExporter` utility is located in the TimesTen instance, you are required to create a TimesTen instance on your development host so that you have access to the `ttExporter` utility. You create a TimesTen instance from a TimesTen installation. A TimesTen installation is created when you unzip the TimesTen distribution.

You must download the TimesTen distribution and unzip it to create a TimesTen installation before beginning these steps. You may have already completed this process if you chose to build the TimesTen container image.

1. If you have not already done so, download and unzip the TimesTen distribution into a directory on your development host.
2. On your development host from a directory of your choice, create a directory for the TimesTen instance. This example assumes you have previously created the `/scratch/ttuser` directory. The example creates the `/scratch/ttuser/instance1_exporter_dir` directory.

   ```
   mkdir /scratch/ttuser/instance1_exporter_dir
   ```

3. Create the TimesTen instance located in the TimesTen installation directory. Replace the following:
   - *`installation_dir`*: Name of the TimesTen installation directory. This is the directory where you unzipped the TimesTen distribution.
   - `tt26.1.1.1.0`: TimesTen release number in `tt`*`dottedrelease`* format, where *`dottedrelease`* is `26.1.1.1.0` in this example.
   - `instance1_exporter`: Name of the TimesTen instance.
   - `/scratch/ttuser/instance1_exporter_dir`: Location of the TimesTen instance. You created this directory in the previous step.

   ```
   ./installation_dir/tt26.1.1.1.0/bin/ttInstanceCreate -name
   instance1_exporter -location /scratch/ttuser/instance1_exporter_dir
   ```

   The output is similar to the following:

   ```
   Creating instance in /scratch/ttuser/instance1_exporter_dir/
   instance1_exporter ...

   NOTE: The TimesTen daemon startup/shutdown scripts have not been installed.

   The startup script is located here :
           '/scratch/ttuser/instance1_exporter_dir/instance1_exporter/startup/
   tt_instance1_exporter'

   Run the 'setuproot' script :
           /scratch/ttuser/instance1_exporter_dir/instance1_exporter/bin/
   setuproot -install
   This will move the TimesTen startup script into its appropriate location.
   ```

```
The 22.1 Release Notes are located here :
  '/scratch/ttuser/installation_dir/tt26.1.1.1.0/README.html'

Instance created successfully.
```

4. Set the `TIMESTEN_HOME` environment variable. You must set this variable before you run the `ttExporter` utility. This example uses the `bash` Bourne-type shell.

   ```
   . /scratch/ttuser/instance1_exporter_dir/instance1_exporter/bin/ttenv.sh
   ```

   The output is similar to the following, with not all output shown:

   ```
   LD_LIBRARY_PATH set to ...
   ...
   PATH set to ...
   ...
   CLASSPATH set to ...
   TIMESTEN_HOME set to /scratch/ttuser/instance1_exporter_dir/
   instance1_exporter
   ```

You successfully created the TimesTen instance on your development host. You are now ready to use the `ttExporter` utility to create the certificates.

Create Certificates

There are certificates that are necessary in order to use Transport Layer Security (mutual TLS)/https. They are as follows:

- Server certificate: A self-signed certificate that is stored in an Oracle Wallet. This certificate is used by the TimesTen exporter. The name of the Oracle Wallet is `cwallet.sso`.
- Exported server certificate: The self-signed server certificate in PEM format. This certificate is required for your Prometheus configuration.
- Client certificate and client private key: The client certificate and the client private key required for your Prometheus configuration.

The following steps show you how to create these certificates:

1. Check that the `TIMESTEN_HOME` environment variable is set. You set this environment variable in a previous step. See Before You Begin.

   ```
   echo $TIMESTEN_HOME
   ```

   The output is the following:

   ```
   /scratch/ttuser/instance1_exporter_dir/instance1_exporter
   ```

2. On your development host, from a directory of your choice, create a subdirectory to store an Oracle Wallet. This example creates the `exportercertdir` directory.

   ```
   mkdir -p exportercertdir
   ```

3. Create the self-signed server certificate. This certificate is stored as an Oracle Wallet. The name of the file that contains the Oracle Wallet is `cwallet.sso`. It contains the certificate

information required by the TimesTen exporter. Later, you will use a Kubernetes Secret to place the `cwallet.sso` Oracle Wallet file into the `/ttconfig/exporterWallet` location of the `exporter` container.

```
ttExporter -create-server-certificate -certificate-common-name
*.samplecertsecret.mynamespace.svc.cluster.local -certificate-alt-names
*.samplecertsecret.mynamespace.svc.cluster.local -certificate-directory
exportercertdir
```

The `-certificate-common-name` and `-certificate-alt-names` `ttExporter` options are required. For detailed information on these options, see ttExporter in the *Oracle TimesTen In-Memory Database Reference*.

The `-certificate-common-name` option is the Common Name (CN) that is included in the certificate. It matches the DNS name where the certificate is installed. This CN can contain only one name. Single-level wildcards are acceptable. In this example, the CN name is `*.`*`samplecertsecret`*`.`*`mynamespace`*`.svc.cluster.local`, where:

- * is a single level wildcard.
- `samplecertsecret` is the name of your TimesTenClassic object.
- *`mynamespace`* is the name of your namespace.
- `svc.cluster.local` completes the required format for the DNS name.

The `-certificate-alt-names` option is the Subject Alternative Name (SAN) that is included in the certificate. This name includes the CN mentioned previously as well as any other DNS names that need access to the TimesTen Exporter. Single level wildcards are acceptable. In this example, the SAN name includes only the CN name. Specifically, the SAN name is `*.`*`samplecertsecret`*`.`*`mynamespace`*`.svc.cluster.local`, where:

- * is a single level wildcard.
- `samplecertsecret` is the name of your TimesTenClassic object.
- *`mynamespace`* is the name of your namespace.
- `svc.cluster.local` completes the required format for the DNS name.

Since these options require you to specify the name of the TimesTenClassic object and the name of your namespace, you must know these names before completing this step. In addition, you must use these same names when defining your TimesTen Classic object.

4. Export the server certificate.

   ```
   ttExporter -export-server-certificate exportercertdir/server.crt -
   certificate-directory exportercertdir
   ```

   This command exports the server certificate in PEM format. In this example, the name of the file that contains the certificate is `server.crt`. Save this file. You need it later when configuring Prometheus.

5. Create and export the client certificate and the client private key.

   ```
   ttExporter -export-client-certificate exportercertdir/client.crt -export-
   client-private-key exportercertdir/key.crt -certificate-directory
   exportercertdir
   ```

This command creates the client certificate. In this example, the contents of the client certificate is stored in the `client.crt` file. The example also creates the client private key and stores its contents in the `key.crt` file. Save these files. You need them later when configuring Prometheus.

6. (Optional): Verify the certificates are created.

   ```
   ls -a exportercertdir
   ```

   The output is similar to the following:

   ```
   .   client.crt  server.crt
   ..  key.crt     .ttwallet.BA0F2D86-B6D2-4095-A4D0-CDF1FF89E9BF
   ```

   Verify the `ttExporter` utility has created the Oracle Wallet.

   ```
   ls -a exportercertdir/.ttwallet*
   ```

   The output is the following:

   ```
   .  ..  cwallet.sso
   ```

You have successfully created the server certificate, the client certificate, and the client private key. Make a note of these files and their location. You need them later. Specifically, you need to specify the `cwallet.sso` Oracle Wallet file when you create the Kubernetes Secret. See Create a Kubernetes Secret Containing an Oracle Wallet. In addition, you need to specify the `server.crt`, the `client.crt`, and the `key.crt` files later when you configure Prometheus.

Note

Configuring Prometheus is outside the scope of this book. For information on configuring Prometheus, see About Configuring the TimesTen Exporter and Prometheus with Client Certificate Authentication in the *Oracle TimesTen In-Memory Database Monitoring and Troubleshooting Guide*.

Create a Kubernetes Secret Containing an Oracle Wallet

The following steps show you how to create a Kubernetes Secret for an Oracle Wallet. This Oracle Wallet contains the self-signed server certificate. You created the Oracle Wallet in Create Certificates.

1. On your development host, from a directory of your choice, create an empty subdirectory for the Oracle Wallet (the `cwallet.sso` file). This example creates the `walletdir` subdirectory.

   ```
   mkdir -p walletdir
   ```

2. Copy the `cwallet.sso` Oracle Wallet to the directory.

   ```
   cp exportercertdir/.ttwallet*/cwallet.sso walletdir/cwallet.sso
   ```

In this example, the Oracle Wallet is located in the `exportercertdir/.ttwallet*/cwallet.sso walletdir` directory. You created this directory in Create Certificates.

3. Create the Kubernetes Secret for the Oracle Wallet. Ensure to specify the `/exporterWallet` directory.

   ```
   kubectl create secret generic prometheuscert --from-
   file=exporterWallet=walletdir/cwallet.sso
   ```

   The `kubectl create generic secret` command does the following:

   - Creates the `prometheuscert` Kubernetes Secret.
   - Includes the `exporterWallet` metadata file. This file is required when including the `cwallet.sso` file in the Secret.
   - Defines `walletdir` as the location for the `cwallet.sso` file.
   - Defines the `cwallet.sso` file as the name of the Oracle Wallet file.

   The output is the following:

   ```
   secret/prometheuscert created
   ```

You have successfully created the Kubernetes Secret. Make a note of the name of the Secret. You use it later when you create your TimesTenClassic object.

Define and Deploy a TimesTenClassic Object

Let's define a TimesTenClassic object with the appropriate information such that the TimesTen Operator automatically provisions the TimesTen exporter in a separate container within each Pod that is running TimesTen. Let's use the `.spec.ttspec.prometheus.certSecret` datum to instruct the TimesTen Operator to use the Oracle Wallet located in the Kubernetes Secret that you previously created. (You created this Secert in Create a Kubernetes Secret Containing an Oracle Wallet).

1. Define a TimesTenClassic object.

   ```
   vi samplecertsecret.yaml

   apiVersion: timesten.oracle.com/v4
   kind: TimesTenClassic
   metadata:
     name: samplecertsecret
   spec:
     ttspec:
       storageClassName: oci-bv
       storageSize: 250G
       image: container-registry.oracle.com/timesten/timesten:26.1.1.1.0
       imagePullSecret: sekret
       prometheus:
         certSecret: prometheuscert
         port: 7777
       dbConfigMap:
       - samplecertsecret
   ```

   Note the following:

- The `.spec.ttspec.prometheus` clause is specified. The TimesTen Operator provisions a TimesTen exporter container in each TimesTen Pod.
- The `.spec.ttspec.prometheus.certSecret` datum is specified. The value of this datum is the name of the Kubernetes Secret containing the Oracle Wallet you previously created.
- The TimesTen exporter is listening on port `7777`.

2. Create the TimesTenClassic object from the contents of the YAML file.

```
kubectl create -f samplecertsecret.yaml
```

The output is the following:

```
configmap/samplecertsecret created
timestenclassic.timesten.oracle.com/samplecertsecret created
```

3. Wait a few minutes then confirm the TimesTenClassic object is in the `Normal` state. Confirm also that the TimesTen Operator provisioned a TimesTen exporter container in each TimesTen Pod.

```
kubectl get ttc samplecertsecret
```

Output.

```
NAME               STATE    ACTIVE               AGE
samplecertsecret   Normal   samplecertsecret-0   6m19s
```

Confirm there is a TimesTen exporter container.

```
kubectl get pods
```

Output.

```
NAME                                  READY   STATUS    RESTARTS   AGE
samplecertsecret-0                    3/3     Running   0          2m59s
samplecertsecret-1                    3/3     Running   0          2m59s
timesten-operator-7f77c749fd-lkhtr    1/1     Running   0          60m
```

The TimesTen Operator provisioned three containers for each TimesTen Pod. One container is running the TimesTen exporter. The TimesTen exporter is listening on port `7777` and functions as an https server.

Your next step is to edit the appropriate Prometheus configuration files to cause Prometheus to scrape TimesTen metrics. For more information about configuring Prometheus, see https://prometheus.io/docs/prometheus/latest/configuration/configuration/.