Services Toolkit for VMware Tanzu Application Platform v0.9

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You can find the most up-to-date technical documentation on the VMware by Broadcom website at:

https://docs.vmware.com/

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Contents

About Services Toolkit

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Services Toolkit is a collection of Kubernetes-native components supporting the discoverability, life-cycle management (CRUD), and connectivity of service resources (databases, message queues, DNS records, and so on) on Kubernetes.

The toolkit is currently comprised of the following components:

- Resource Claims
- Service Offering
- Service API Projection (experimental)
- Resource Replication (experimental)

Each component has value independent of the others, however the most powerful and valuable use cases can be unlocked by combining them together in unique and interesting ways. For a use case with examples of what can be done with the toolkit, see Getting Started.

For an example of how to consume AWS services with Services Toolkit, see either Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK) or Consuming AWS RDS on Tanzu Application Platform (TAP) with Crossplane.

Motivation

Application teams need supporting service resources (databases, message queues, DNS records, and so on) to develop and run their applications. They do not want the burden of running these services themselves, so many organizations provide ticketing systems that allow application teams to manually make requests for new service resources to be created and managed for them. This process often takes weeks.

In the cloud, application teams have self-service access to create new managed resources that you can provision with API calls, such as RDS. Services Toolkit aims to provide a set of modular tools that you can use to provide a similar self-service experience to that of the cloud for service resources running on Tanzu.

Component Overview

Here is a brief overview of the components comprising Services Toolkit.

Resource claims

Resource claims enable application teams to express which service resources their applications require without having to know the intricacies of the service resource fulfilling the request. This replaces the traditional ticketing system previously mentioned with a model of application teams claiming resources and service operators providing resources to be claimed. This provides a self-service experience for the developer, but gives the service operators ultimate control of the service resources.

This also means application teams can request a service resource without having to know the exact name or namespace of the pre-provisioned service resource. Instead they express requirements using more meaningful metadata. For example, type, protocol, provider, and version. The claim is then fulfilled against an existing service resource using rules chosen by the service operator. This enables application teams to focus on their application and its dependencies.

To learn more about claims, see Resource claims. § To learn more about whether to use `ResourceClaims` or `ClassClaims`, see When to use `ClassClaim` vs `ResourceClaim`.

Service Offering

To discover service resources and understand how to use them, application operators need access to a rich set of metadata that describes the semantics and management capabilities of the corresponding Service Resource Lifecycle APIs.

The fundamental building blocks of Service Resource Lifecycle APIs are aggregated APIs or CRDs, and these already define some metadata. However, this only consists of Kubernetes-level API descriptions, such as name and field.

Although this metadata is useful, application operators require more holistic information that covers details such as service-level management capabilities, QoS guarantees, and relationships between different resource types the API exposes. Application operators also require other information that aids discovery by application operators and higher-level tooling aimed at that role, such as keywords, icons, and so on.

Some metadata surfaced by service description and offering relate not only to the Service Resource Lifecycle API itself, but also to the specifics of the underlying infrastructure, such as the number and the topology of worker nodes in the Service Cluster, or the particular CSI and CNI implementations configured for the cluster.

For example, a service resource that is relevant to MySQL cannot claim high-availability for the provisioned databases if the service cluster in which the individual MySQL pods run consists of only a single worker node.

Because of this, the service operator is deemed responsible for ensuring that the correct level of accurate metadata is specified for a service resource. Service description and offering enables the association of metadata with service resources and surfacing it to application operators. The service operator can provide this metadata, and service authors can provide infrastructure-agnostic metadata, such as data that describes the relationships between different API resource types.

To learn more about service offering, see Service offering.

Service API Projection and Resource Replication (experimental)

VMware recommends that customers separate application and service infrastructure, which is done in their production environments. Benefits of this segmentation of infrastructure include:

- **Dedicated cluster requirements for workload or service clusters:** For example, service clusters might need access to SSDs.
- **Different cluster life cycle management:** Upgrades to service clusters can occur more cautiously.
- **Unique compliance requirements:** Data might have different compliance needs because it is stored on a service cluster.
- **Separation of permissions and access:** Application teams can only access the clusters where their applications are running.

One way to address these needs in a Kubernetes multicluster world is to split clusters into application workload clusters and service clusters, and then allow application teams to consume service resource APIs from their application workload cluster, with reconciliation of resources occurring on services clusters.

To learn more about service API projection and resource replication, see Service API projection and service resource replication.

Release notes

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

v0.9.2

Release Date: March 6, 2023

- Patch release
  - Bump dependencies to address CVE-2022-27664.

v0.9.1

Release Date: February 16, 2023

- Patch release
  - Bump dependencies to address CVE-2023-0286.
  - Bump dependencies to address CVE-2022-1996.

v0.9.0

Release Date: January 10, 2023

- Added new `ClassClaim` API that allows claims for service instances to be created by referring to a `ClusterInstanceClass`.
  - See When to use ClassClaim vs ResourceClaim
  - See Introducing different service implementations in different environments
- Added corresponding `tanzu services class-claims` CLI plug-in command
- The `tanzu services claims` CLI plug-in command is now considered to be deprecated
  - It has been hidden from help text output, but will still continue to work until officially removed after the deprecation period
  - The new `tanzu services resource-claims` command provides the same functionality
- Added support for Openshift 4.11
- Added support for Kubernetes 1.25

- All containers are now configured with read-only root filesystems

v0.8.3

Release Date: March 6, 2023

- Patch release
  - Bump dependencies to address CVE-2022-27664.

v0.8.2

Release Date: February 16, 2023

- Patch release
  - Bump dependencies to address CVE-2023-0286 and CVE-2022-1996

v0.8.1

Release Date: November 15, 2022

- `libssl3` has been updated to `3.0.2-0ubuntu1.7` to resolve CVE-2022-3786.
- `libssl3` has been updated to `3.0.2-0ubuntu1.7` to resolve CVE-2022-3602.

v0.8.0

Release Date: October 11, 2022

- Added support for Openshift
- Added support for Kubernetes 1.24
- Created documentation and reference Service Instance Packages for new Cloud Service Provider integrations:
  - Azure Flexible Server (Postgres) using the Azure Service Operator
  - Azure Flexible Server (Postgres) using Crossplane
  - Google Cloud SQL (Postgres) using Config Connector
  - Google Cloud SQL (Postgres) using Crossplane
- Formally defined the Service Operator user role (see Services Toolkit Terminology and User roles)
- `tanzu services` CLI plug-in - improved info messages for deprecated commands

v0.7.1

Release Date: July 12, 2022

- Services Toolkit now integrates with Amazon RDS using the ACK Operator. See Consuming AWS RDS on Tanzu Application Platform with AWS Controllers for Kubernetes (ACK).
- Services Toolkit now integrates with Amazon RDS by using Crossplane. See Consuming AWS RDS on Tanzu Application Platform with Crossplane.

- New `ClusterInstanceClass` supports service instance abstraction. It is available using `tanzu service classes list` in `v0.3.0` of the Services plug-in for Tanzu CLI.
- You can now use the `InstanceQuery` API to discover claimable resources. It is available using `tanzu service claimable list --class CLASS` in `v0.3.0` of the Services plug-in for Tanzu CLI.
- ResourceClaims no longer mutate service resources with an annotation to mark a claimed resource. Instead it uses Kubernetes Leases.
- ResourceClaims no longer require the `update` permission when adding new service resources to Tanzu Application Platform.
- ResourceClaims now aggregate on ClusterRoles for service resources with the standard `servicebinding.io/controller: "true"` label from the Service Binding specification for Kubernetes This label is recommended over the existing `resourceclaims.services.apps.tanzu.vmware.com/controller: "true"` label, although the old label continues to work as expected.
- Performance enhancements to ResourceClaim controller tracker.
- All Services Toolkit components now conform to Tanzu Application Platform logging standards.
- Deprecation warning: `tanzu service types list` and `tanzu service instances list` commands are now deprecated. These commands are hidden from help text but remain functional if invoked. VMware intends to support these commands for either two additional minor releases (v0.6.0 of the CLI plug-in) or after one year (2023-07-12), whichever comes later. VMware recommends using `tanzu service class` and `tanzu service claimable` commands in place of `tanzu service type` and `tanzu service instance` from now on.

Bug Fixes

- ResourceClaims no longer overwrite existing secrets on cross namespace claims.
- Fix ResourceClaims incorrectly logging resource requests as part of tracking.
- ResourceClaims `.status.ClaimedResourceRef.Namespace` is now set for same namespace claims.

v0.6.0

Release Date: April 12, 2022

- Introduced default aggregating ClusterRoles for Tanzu Application Platform's App Editors, App Viewers, and App Operators.
- The `ResourceClaim` and `ResourceClaimPolicy` CRD category `resourceclaims` was removed to avoid clashes with the `ResourceClaim` resource plural.
- Fixed kubectl table output of `ResourceClaimPolicy`.
- All Services Toolkit pods now adhere to Restricted Pod Security Standards.
- Services plug-in for Tanzu CLI v0.2.0 includes the following changes:

- Allows the management of `ResourceClaims` using `tanzu service claims <list/get/create/delete>`.
- Alpha Warnings are now output to `stderr` instead of `stdout`.

v0.5.1

Release Date: March 3, 2022

- Fixed a race condition issue that might lead to a failure of the `services-toolkit` controller manager when a new `ResourceClaim` is being created whilst another is being deleted.
- Fixed an issue that caused `kapp-controller` to unnecessarily reconcile continuously.
- Services plug-in for Tanzu CLI at v0.1.2 now supports interactions with GCP clusters.

v0.5.0

Release Date: January 11, 2022

- Resource Claims now support cross namespace claiming by using `ResourceClaimPolicy` objects.
- Resource Claims are now exclusive. Multiple `ResourceClaim` objects can not claim a single service resource.
- Services Toolkit, specifically Resource Claims, now depends on at least `v0.5.0` of carvel-secretgen-controller in GitHub.
- Do not block claim deletion when it can not find GVR.

Breaking changes

- Rename `ClusterServiceResource` to `ClusterResource`
- Move `ClusterResource`, `ClusterExampleUsage` and `ResourceClaim` to `services.apps.tanzu.vmware.com` APIGroup
- Move `DownstreamClusterLink`, `UpstreamClusterLink`, `APIExportRoleBinding`, `APIResourceImport` and `ClusterAPIGroupImport` to `projection.apiresources.multicluster.x-tanzu.vmware.com` APIGroup
- Move `ClusterResourceExportMonitor`, `ClusterResourceImportMonitor`, `ResourceExportMonitorBinding`, `ResourceImportMonitorBinding`, `SecretExport` and `SecretImport` to `replication.apiresources.multicluster.x-tanzu.vmware.com` APIGroup
- Add the label prefix `replication.apiresources.multicluster.x-tanzu.vmware.com` for the `monitored-resource-*` labels of `ClusterResourceExportMonitor` and `ClusterResourceImportMonitor`
- Rename the Resource Claims finalizer from `claim.services.apps.tanzu.vmware.com/finalizer` to `resourceclaims.services.apps.tanzu.vmware.com/finalizer`. Existing `ResourceClaims` must be updated to remove the old finalizer to be deleted.

- Rename the Resource Claims aggregation `ClusterRole` label from `services.apps.tanzu.vmware.com/aggregate-to-resource-claims: "true"` to `resourceclaims.services.apps.tanzu.vmware.com/controller: "true"`. Existing aggregated roles must be updated to have the new label.
- Edit all deployment resources naming to use `services-toolkit` rather than the outdated `scp-toolkit`.

Getting started

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

The quickest and easiest way to get started with Services Toolkit is to experience it as part of Tanzu Application Platform. For more information about the main use cases, tools and APIs powered by the toolkit, see About consuming services on Tanzu Application Platform.

In addition, a number of additional use cases are available:

- Introducing Different Service Implementations in Different Environments
- Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK)
- Consuming AWS RDS on Tanzu Application Platform (TAP) with Crossplane
- Consuming Azure FlexibleServer PostgreSQL on Tanzu Application Platform (TAP) with Azure Server Operator v2
- Direct Secret References
- Dedicated Service Clusters

Install

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Services Toolkit is packaged and distributed by using the carvel set of tools.

The Services Toolkit carvel package is currently published to the Tanzu Application Platform package repository.

There are two options for installation:

- To install it as part of a wider Tanzu Application Platform installation, see Installing Tanzu Application Platform.
- To install it as an individual package on its own, see Install Services Toolkit.

Consuming Services on Tanzu Application Platform

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

The best way to get started and to learn about Services Toolkit is to follow the getting started guides published for Tanzu Application Platform. Two guides are available, one pertaining to the roles of the Service Operator and Application Operator, and the other, complimentary guide pertaining to the role of the Application Developer. These guides are linked below.

- Set up services for consumption by developers
- Consume services on Tanzu Application Platform

Uninstall

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

To uninstall Services Toolkit run:

```
tanzu package installed delete services-toolkit
```

Use Cases and Walkthroughs

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This section of the documentation covers common use cases and walkthroughs to help you learn about the capabilities and usage of Services Toolkit. Please refer to and select a use case of interest from the table of contents.

Introducing Different Service Implementations in Different Environments

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes how to use Services Toolkit to have a claim resolve to a different backing service resource depending on which environment it is in. This can be used in order to remove the need for application operators to change their `ClassClaim` and `Workload` as they are promoted through environments, whilst also enabling service operators to change the backing service implementation without further configuration.

A broad overview of what this looks like is the following:

- There are three clusters: `iterate`, `run-test`, and `run-production`.
- In each cluster, the Services Operator has created a `ClusterInstanceClass` called `postgres`.
    - In the `iterate` cluster, this points at in-cluster bitnami helm instance of postgres.
    - In the `run-test` cluster, this points at in-cluster VMware Tanzu Postgres instances of postgres.
    - In the `run-production` cluster, this points at resources representing instances running in Amazon AWS RDS.
- The App Operator creates a `ClassClaim`, this gets applied along with a consuming `Workload`.
    - When it is applied in `iterate` it resolves to a helm chart instance.
    - When it is promoted to `run-test` it resolves to a VMware Tanzu Postgres instance.
    - When it is promoted in `run-production` it resolves to an Amazon AWS RDS instance.
    - Note that the definition of the `ClassClaim` remains identical across the clusters, so there is less work for the Application Operator.

> **Note**
>
> The backing service implementations and environment layouts used in this use case are arbitrary and should not be taken as recommendations or requirements.

Prerequisites

This usecases requires three separate clusters with TAP 1.4.0 or higher installed in each.

Setup Postgres Bitnami Helm Chart on the `iterate` cluster

Select an arbitrary cluster, we will call this the `iterate` cluster. For this cluster, we will create an instance of the Bitnami helm chart for postgres.

1. Apply the RBAC necessary for the Services Toolkit operator to read the `Secrets`:

```
# `iterate`-stk-secret-reader.yaml
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups: [""]
  resources: ["secrets"]
  verbs: ["get", "list", "watch"]
```

2. Add the Bitnami chart repository:

```
helm repo add bitnami https://charts.bitnami.com/bitnami
```

3. Create an instance of the helm chart:

```
# Make sure to set the database name and user
helm install postgres bitnami/postgresql \
  --set auth.username=test \
  --set auth.database=test
```

4. Apply the following `SecretTemplate` resource and the necessary RBAC permissions. This will create a `Secret` with the postgres credentials which our workload application can consume. It gets these credentials from the helm-created resources and is specifically labelling the `Secret` with the `services.apps.tanzu.vmware.com/class: bitnami-postgres` label. Later on, this label will be used by the `postgres` class to match instances of the class.

```
# helm-secret-template.yaml
---
apiVersion: secretgen.carvel.dev/v1alpha1
kind: SecretTemplate
metadata:
  name: helm-postgres
spec:
  serviceAccountName: helm-reader
  inputResources:
  - name: pod
    ref:
      apiVersion: v1
      kind: Pod
      name: postgres-postgresql-0
  - name: service
    ref:
      apiVersion: v1
      kind: Service
      name: postgres-postgresql
  - name: secret
    ref:
      apiVersion: v1
```

```
      kind: Secret
      name: $(.pod.spec.containers[?(@.name=="postgresql")].env[?(@.name=="POST
GRES_PASSWORD")].valueFrom.secretKeyRef.name)
  template:
    metadata:
      labels:
        services.apps.tanzu.vmware.com/class: bitnami-postgres
    stringData:
      type: postgresql
      port: $(.service.spec.ports[0].port)
      database: $(.pod.spec.containers[0].env[?(@.name=="POSTGRES_DB")].value)
      host: $(.service.spec.clusterIP)
      username: $(.pod.spec.containers[0].env[?(@.name=="POSTGRES_USER")].value
)
    data:
      password: $(.secret.data.password)
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: helm-reader
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: helm-reader
rules:
- apiGroups: [""]
  resources: ["services", "secrets", "pods"]
  verbs: ["get", "list", "watch"]
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: sa-rb-helm
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: helm-reader
subjects:
- kind: ServiceAccount
  name: helm-reader
```

Note

If you use this YAML to create a postgres instance in a namespace other than `default`, then a `ResourceClaimPolicy` must be created that allows `Secrets` with the same labels in that namespace to be claimed from `default`.

Setup VMware Tanzu SQL with Postgres on the `run-test` cluster

Select a different arbitrary cluster, we will call this the `run-test` cluster. For this cluster, we will create a instance of the VMware Tanzu SQL with Postgres for Kubernetes.

1. Follow the instructions at Installing a Tanzu Postgres Operator in order to have the operator.
2. Follow the instructions at Deploying a Postgres Instance in order to have a deployed instance.

> **Note**
>
> If the instances deployed are in a namespace other than `default`, a `ResourceClaimPolicy` must be created that allows `Postgres` in that namespace to be claimed from `default`.

Setup Amazon AWS RDS on the `run-production` cluster

Select a different arbitrary cluster, we will call this the `run-production` cluster. For this cluster, we will create a instance of the Amazon RDS .

In this scenario, we can either:

- Follow the instructions for Consuming AWS RDS on Tanzu Application Platform with AWS Controllers for Kubernetes (ACK). Stop when the Create an RDS service instance step is finished.

or

- Follow the instructions for Consuming AWS RDS on Tanzu Application Platform with Crossplane. Stop when the Provision RDS PostgreSQL instance step is finished.

> **Note**
>
> If the instances deployed are in a namespace other than `default`, a `ResourceClaimPolicy` must be created that allows `Secrets` with the same labels in that namespace to be claimed from `default`.

Create the `ClusterInstanceClasses`

The `ClusterInstanceClass` will be the discovery interface that our `ClassClaim` will use in order to claim a database resource for our application workload. In order for the `ClassClaim` to work in every cluster we apply it, the `ClusterInstanceClass` must have the same name as that is what identifies it to the `ClassClaim`.

The `iterate` cluster

On the `iterate` cluster, we have helm chart instances of postgres. In order to create a `ClusterInstanceClass` through which service instances can be claimed and consumed, we need to define what is the claimable resource of these helm chart instances are. Since nothing in the chart follows the `ProvisionedService` duck type of the `ServiceBinding` spec, we will use the `Secret` produced by the `SecretTemplate` we applied.

This results in the following `ClusterInstanceClass` that we should apply to the `iterate` cluster:

```
# iterate-clusterinstanceclass.yaml
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: postgres
spec:
  description:
    short: Postgres instances
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: bitnami-postgres
```

The `run-test` cluster

On the `run-test` cluster, we have instances of VMware Tanzu Postgres. Again, we need to configure the class to match against the claimable resources for these instances. `Postgres` resource provided by this operator follows the `ProvisionedService` duck type of the `ServiceBinding` spec, so we will define it as the claimable resource.

This results in the following `ClusterInstanceClass` that we should apply to the `run-test` cluster:

```
# run-test-clusterinstanceclass.yaml
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: postgres
spec:
  description:
    short: Postgres instances
  pool:
    kind: Postgres
    group: sql.tanzu.vmware.com
```

The `run-production` cluster

On the `run-production` cluster, we have instances of Amazon AWS RDS. Again, we need to configure the class to match against the claimable resources for these instances. nothing we created follows the `ProvisionedService` duck type of the `ServiceBinding` spec, we will use the `Secret` produced by either:

- the `SecretTemplate` in the ACK usecase.
- the `PostgreSQLInstance` in the Crossplane usecase.

Both have the same label on their `Secret` so we can use the following `ClusterInstanceClass` and apply it to the `run-production` cluster:

```
# run-production-clusterinstanceclass.yaml
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
```

```
metadata:
  name: postgres
spec:
  description:
    short: Postgres instances
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: rds-postgres
```

Create and Promote the `Workload` and `ClassClaim`

Firstly, we create our Cartographer `Workload`:

```
# workload.yaml
---
apiVersion: carto.run/v1alpha1
kind: Workload
metadata:
  name: pet-clinic
  namespace: default
  labels:
    apps.tanzu.vmware.com/workload-type: web
    app.kubernetes.io/part-of: pet-clinic
spec:
  params:
  - name: annotations
    value:
      autoscaling.knative.dev/minScale: "1"
  env:
  - name: SPRING_PROFILES_ACTIVE
    value: postgres
  serviceClaims:
  - name: db
    ref:
      apiVersion: services.apps.tanzu.vmware.com/v1alpha1
      kind: ClassClaim
      name: postgres
  source:
    git:
      url: https://github.com/sample-accelerators/spring-petclinic
      ref:
        branch: main
        tag: tap-1.2
```

This file can be generated and applied with following `tanzu` command:

```
tanzu apps workload create my-workload \
   --git-repo https://github.com/sample-accelerators/spring-petclinic \
   --git-branch main \
   --git-tag tap-1.2 \
   --type web \
   --label app.kubernetes.io/part-of=spring-petclinic \
   --annotation autoscaling.knative.dev/minScale=1 \
   --env SPRING_PROFILES_ACTIVE=postgres \
   --service-ref db=services.apps.tanzu.vmware.com/v1alpha1:ClassClaim:postgres
```

And we then want to create the `ClassClaim` it references:

```
# classclaim.yaml
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClassClaim
metadata:
  name: postgres
  namespace: default
spec:
  classRef:
    name: postgres
```

This file can be generated and applied with following `tanzu` command:

```
tanzu services class-claim create postgres --class postgres
```

For more details on this command, see the Create ClassClaims.

Apply both these files to the `iterate` cluster, and we should find that our application is running and using the helm-created postgres instance.

As we apply the exact same files to the `run-test` and `run-production` clusters, we will find that the Workload uses the VMware Tanzu Postgres Operator and Amazon AWS RDS postgres instances respectively.

Direct Secret References

Note

Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This use case leverages direct references to Kubernetes `Secret` resources to enable developers to connect their application workloads to almost any backing service, including backing services that:

- are running external to Tanzu Application Platform
- do not adhere to the ProvisionedService of the Service Binding Specification for Kubernetes in GitHub.

The following example demonstrates a procedure to bind a new application on Tanzu Application Platform to an existing PostgreSQL database that exists in Azure.

Depending on your Kubernetes distribution and the backing Service you are hoping to connect to your Tanzu Application Platform workloads, there could be extra work to set up networking between the workload and the service endpoint and to obtain the credentials for the backing service. This example assumes the credentials are available and networking has been set up.

1. Create a Kubernetes secret resource similar to the following example:

   ```
   # external-azure-db-binding-compatible.yaml
   ---
   ```

```
apiVersion: v1
kind: Secret
metadata:
  name: external-azure-db-binding-compatible
type: Opaque
stringData:
  type: postgresql
  provider: azure
  host: EXAMPLE.DATABASE.AZURE.COM
  port: "5432"
  database: "EXAMPLE-DB-NAME"
  username: "USER@EXAMPLE"
  password: "PASSWORD"
```

Kubernetes secret resources must abide by the Well-known Secret Entries specifications in GitHub. If you are planning to bind this secret to a Spring-based application workload and want to take advantage of the auto-wiring feature, this secret must also contain the properties required by Spring Cloud Bindings in GitHub.

2. Apply the YAML file by running:

```
kubectl apply -f external-azure-db-binding-compatible.yaml
```

3. Grant sufficient RBAC permissions to Services Toolkit to be able to read the secrets specified by the class:

```
# stk-secret-reader.yaml
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
  - list
  - watch
```

4. Apply your changes by running:

```
kubectl apply -f stk-secret-reader.yaml
```

5. Create a claim for the newly created secret by running:

> **Note**
>
> Create the claim in the same namespace as your workload. If your workload is in a different namespace to the one currently targeted, add the `--namespace` flag to the above command.

```
tanzu service resource-claim create external-azure-db-claim \
  --resource-name external-azure-db-binding-compatible \
  --resource-kind Secret \
  --resource-api-version v1
```

6. Obtain the claim reference of the claim by running:

```
tanzu service resource-claim list -o wide
```

Expect to see the following output:

```
NAME                         READY  REASON  CLAIM REF
external-azure-db-claim      True           services.apps.tanzu.vmware.com/v1alpha1
:ResourceClaim:external-azure-db-claim
```

7. Create an application workload by running a command similar to the following example:

Example:

```
tanzu apps workload create WORKLOAD-NAME \
  --git-repo https://github.com/sample-accelerators/spring-petclinic \
  --git-branch main \
  --git-tag tap-1.2 \
  --type web \
  --label app.kubernetes.io/part-of=spring-petclinic \
  --annotation autoscaling.knative.dev/minScale=1 \
  --env SPRING_PROFILES_ACTIVE=postgres \
  --service-ref db=REFERENCE
```

Where:

- `WORKLOAD-NAME` is the name of the Application Workload. For example, `pet-clinic`.
- `REFERENCE` is the value of the `CLAIM REF` for the newly created claim in the output of the last step.

Dedicated Service Clusters (using experimental Projection and Replication APIs)

Note

Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Caution: This use case leverages experimental APIs. Do not use it in a production environment.

This use case leverages the experimental API Projection and Resource Replication APIs to separate application workloads and service instances onto separate Kubernetes clusters. There are several reasons for it:

- **Dedicated cluster requirements for workload or service clusters:** Service clusters, for example, might need access to more powerful SSDs.

- **Different cluster life cycle management:** Upgrades to service clusters can occur more cautiously.
- **Unique compliance requirements:** Data is stored on a service cluster, which might have different compliance needs.
- **Separation of permissions and access:** Application teams can only access the clusters where their applications are running.

The benefits of implementing this use case include:

- The experience for application developers and application operators working on their Tanzu Application Platform cluster is unaltered.
- All complexity in the setup and management of backing infrastructure is abstracted away from application developers, which gives them more time to focus on developing their applications.

> **Note**
>
> This use case currently does not support the federation of core Kubernetes APIs such as Secret. It requires a ProvisionedService API that references a Secret in order to work. This means that use cases such as Direct Service References or Cloud Service Provider use cases, support such as Consuming AWS RDS on TAP, will not work when combined with this use case.

For information about network requirements and possible topology setups, see Topology.

Prerequisites

Meet the following prerequisites before completing this use case walkthrough:

- You have access to a cluster with Tanzu Application Platform installed, henceforth called the application workload cluster.
- You have access to a second, separate cluster with the Services Toolkit package installed, henceforth called the service cluster.
- You downloaded and installed the `tanzu` CLI and the corresponding plug-ins.
- You downloaded and installed the experimental `kubectl-scp` plug-in. For instructions, see Install the kubectl-scp plug-in.
- You set up the `default` namespace on the application workload cluster as your developer namespace to use installed packages. For more information, see Set up developer namespaces to use installed packages.
- The application workload cluster can pull source code from GitHub.
- The service cluster can pull the images required by the RabbitMQ Cluster Kubernetes Operator.
- The service cluster can create LoadBalancer services.

- If you have previously installed the RabbitMQ cluster operator to the application workload cluster as part of Getting started with Tanzu Application Platform, uninstall it from that cluster. This is necessary because of a limitation of the experimental API Projection APIs. To delete the operator, run:

  ```
  kapp delete -a rmq-operator -y
  ```

Walkthrough

Follow these steps to bind an application to a service instance running on a different Kubernetes cluster:

1. As the service operator, link the workload cluster and service cluster together by using the `kubectl scp` plug-in. To do so, run:

   ```
   kubectl scp link --workload-kubeconfig-context=WORKLOAD-CONTEXT --service-kubec
   onfig-context=SERVICE-CONTEXT
   ```

   Where `WORKLOAD-CONTEXT` is your workload context and `SERVICE-CONTEXT` is your service context.

   > **Note**
   >
   > You might need to specify the service cluster Kubernetes API address with `--service-server-address=CLUSTER-EXAMPLE.com:6443>`.
   >
   > This is necessary if running `kubectl get --raw /api` results in an address that is not reachable from the workload cluster or results in an address that doesn't match the CA certificate in the specified service `kubeconfig` entry.

2. Install the RabbitMQ Kubernetes operator in the services cluster by running:

   ```
   kapp -y deploy --app rmq-operator \
    --file https://raw.githubusercontent.com/rabbitmq/cluster-operator/lb-binding/
   hack/deploy.yml \
    --kubeconfig-context SERVICE-CONTEXT
   ```

   Where `SERVICE-CONTEXT` is your service context.

   This operator is installed in the service cluster, but `RabbitmqCluster` service instance life cycles (CRUD) can still be managed from the workload cluster. Use the exact `deploy.yml` specified in the command because this RabbitMQ operator deployment includes specific changes to enable cross-cluster service binding.

3. Verify that you installed the operator by running:

   ```
   kubectl --context SERVICE-CONTEXT get crds rabbitmqclusters.rabbitmq.com
   ```

   Where `SERVICE-CONTEXT` is your service context.

   The `rabbitmq.com/v1beta1` API group is available in the service cluster. The following steps federate the `rabbitmq.com/v1beta1` in the workload cluster. This occurs in two parts, projection and replication.

- Projection applies to custom API groups.
- Replication applies to core Kubernetes resources, such as secrets.

4. Create a `service-instance` namespace in both clusters. API projection occurs between clusters by using namespaces with the same name and that are said to have a quality of namespace sameness.

   For example:

   ```
   kubectl --context WORKLOAD-CONTEXT create namespace service-instances
   kubectl --context SERVICE-CONTEXT create namespace service-instances
   ```

   Where `WORKLOAD-CONTEXT` is your workload context and `SERVICE-CONTEXT` is your service context.

5. Use the `kubectl-scp` plug-in to federate by running:

   ```
   kubectl scp federate \
   --workload-kubeconfig-context=WORKLOAD-CONTEXT \
   --service-kubeconfig-context=SERVICE-CONTEXT \
   --namespace=service-instances \
   --api-group=rabbitmq.com \
   --api-version=v1beta1 \
   --api-resource=rabbitmqclusters
   ```

   Where `WORKLOAD-CONTEXT` is your workload context and `SERVICE-CONTEXT` is your service context.

   Note

   You might need to specify the service cluster Kubernetes API address with `--service-server-address=CLUSTER-EXAMPLE.com:6443`.

   This is necessary if running `kubectl get --raw /api` results in an address that is not reachable from the workload cluster or an address that doesn't match the CA certificate in the specified service `kubeconfig` entry.

6. After federation, verify the `rabbitmq.com/v1beta1` API is also available in the workload cluster by running:

   ```
   kubectl --context WORKLOAD-CONTEXT api-resources
   ```

   Where `WORKLOAD-CONTEXT` is your workload context

7. Advertise that the RabbitmqCluster API is available to developers by applying the following YAML to your workload cluster. Ensure the Tanzu CLI is configured to target the workload cluster for the rest of the steps.

   ```
   ---
   apiVersion: services.apps.tanzu.vmware.com/v1alpha1
   ```

```
kind: ClusterInstanceClass
metadata:
 name: rabbitmq
spec:
 description:
   short: It's a RabbitMQ cluster!
 pool:
   kind: RabbitmqCluster
   group: rabbitmq.com
```

8. Discover the new service and provision an instance from the workload cluster by running:

```
tanzu services classes list
```

The following output appears:

```
tanzu services classes list

NAME      DESCRIPTION
rabbitmq  It's a RabbitMQ cluster!
```

9. Provision a service instance on the Tanzu Application Platform cluster.

For example:

```
# rabbitmq-cluster.yaml
---
apiVersion: rabbitmq.com/v1beta1
kind: RabbitmqCluster
metadata:
 name: projected-rmq
spec:
 service:
   type: LoadBalancer
```

10. Apply the YAML file by running:

```
kubectl --context WORKLOAD-CONTEXT -n service-instances apply -f rabbitmq-clust
er.yaml
```

Where `WORKLOAD-CONTEXT` is your workload context

11. Confirm that the RabbitmqCluster resource reconciles successfully from the workload cluster by running:

```
kubectl --context WORKLOAD-CONTEXT -n service-instances get -f rabbitmq-cluster
.yaml
```

Where `WORKLOAD-CONTEXT` is your workload context

12. Verify that RabbitMQ pods are running in the service cluster, but not in the workload cluster, by running:

```
kubectl --context WORKLOAD-CONTEXT -n service-instances get pods
kubectl --context SERVICE-CONTEXT -n service-instances get pods
```

Where `WORKLOAD-CONTEXT` is your workload context and `SERVICE-CONTEXT` is your service context.

13. Enable cross-namespace claims by creating a `ResourceClaimPolicy` on your workload cluster:

```
# rabbitmq-cluster-policy.yaml
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ResourceClaimPolicy
metadata:
  name: rabbitmq-cluster-policy
  namespace: service-instances
spec:
  consumingNamespaces:
  - default
  subject:
    group: rabbitmq.com
    kind: RabbitmqCluster
```

14. Apply the YAML file by running:

```
kubectl --context WORKLOAD-CONTEXT apply -f rabbitmq-cluster-policy.yaml
```

Where `WORKLOAD-CONTEXT` is your workload context

15. Create a claim for the projected service instance by running:

```
tanzu service resource-claim create projected-rmq-claim \
  --resource-name projected-rmq \
  --resource-kind RabbitmqCluster \
  --resource-api-version rabbitmq.com/v1beta1 \
  --resource-namespace service-instances \
  --namespace default
```

16. Create the application workload by running:

```
tanzu apps workload create multi-cluster-binding-sample \
  --namespace default \
  --git-repo https://github.com/sample-accelerators/rabbitmq-sample \
  --git-branch main \
  --git-tag 0.0.1 \
  --type web \
  --label app.kubernetes.io/part-of=rabbitmq-sample \
  --annotation autoscaling.knative.dev/minScale=1 \
  --service-ref "rmq=services.apps.tanzu.vmware.com/v1alpha1:ResourceClaim:proj
ected-rmq-claim"
```

17. Get the `web-app` URL by running:

```
tanzu apps workload get multi-cluster-binding-sample -n default
```

18. Visit the URL and refresh the page to confirm the app is running by viewing the new message IDs.

Consuming Cloud Services (AWS, Azure and GCP) on Tanzu Application Platform

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This section of the documentation covers integrations of various Cloud Service Providers (AWS, Azure and GCP) into Tanzu Application Platform.

Consuming AWS RDS on Tanzu Application Platform

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This section of the documentation covers integrations of AWS RDS into Tanzu Application Platform. Documentation is provided for both an integration using AWS Controllers for Kubernetes (ACK), as well as an integration using Crossplane.

Consuming AWS RDS on Tanzu Application Platform with AWS Controllers for Kubernetes (ACK)

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes how to use Services Toolkit to allow Tanzu Application Platform workloads to consume AWS RDS PostgreSQL databases.

This topic makes use of AWS Controllers for Kubernetes (ACK) to manage RDS instances in AWS. As such, it is an alternative approach to using Crossplane to achieve the same outcomes.

Prerequisites

- Prerequisites
- Configure your AWS RDS environment

Create service instances that are compatible with Tanzu Application Platform

Installing the ACK service controller for RDS makes available new Kubernetes APIs for interacting with RDS resources from within the Tanzu Application Platform cluster.

```
$ kubectl api-resources --api-group rds.services.k8s.aws

NAME                          SHORTNAMES   APIVERSION                        NAMESPACED   K
IND
dbclusterparametergroups                   rds.services.k8s.aws/v1alpha1     true         D
BClusterParameterGroup
dbclusters                                 rds.services.k8s.aws/v1alpha1     true         D
BCluster
dbinstances                                rds.services.k8s.aws/v1alpha1     true         D
BInstance
dbparametergroups                          rds.services.k8s.aws/v1alpha1     true         D
BParameterGroup
dbsubnetgroups                             rds.services.k8s.aws/v1alpha1     true         D
BSubnetGroup
globalclusters                             rds.services.k8s.aws/v1alpha1     true         G
lobalCluster
```

`DBInstance` is of most interest here because this is the primary API for creating RDS databases. However, there are two important obstacles with this API when considering compatibility with Tanzu Application Platform.

Obstacle 1: `DBInstance` does not adhere to the binding specification

`DBInstance` does not adhere to the Service Binding Specification for Kubernetes. Tanzu Application Platform uses this specification as a contract for ensuring compatibility between different parts of the system. Given that `DBInstance` does not adhere to the specification it means that, by default, it is not possible to claim and bind application workloads to `DBInstance` resources.

Obstacle 2: Creating a `DBInstance` resource on its own is not sufficient

Creating a `DBInstance` resource on its own might not always be enough to create a working, usable instance that can be connected to and utilized.

For example, `DBInstance` defines the field `.spec.masterUserPassword`, which must refer to a secret containing credentials for the instance. As such, the secret resource can be considered a dependent resource of `DBInstance`. Without both of these resources, it is not possible to properly configure the RDS instance as wanted. In many cases, a group of related resources must be created to create something usable.

Solutions

Tanzu Application Platform v1.2 and later enables solutions for both these obstacles.

For example, consider the first obstacle where `DBInstance` does not adhere to the Kubernetes binding specification. One solution is for the authors of the RDS ACK service controller to update the `DBInstance` API to make it adhere to the binding specification. However, this requires code changes to the operator itself, and the authors of the operator might choose not to prioritize it.

Fortunately, there is an alternative solution that doesn't require any code changes to the operator itself while still enabling claiming and binding to RDS instances from within a Tanzu Application

Platform cluster.

This solution uses the `SecretTemplate` API provided by Carvel's secretgen-controller. This API can be used to create binding specification-conforming secrets by identifying and collecting information that resources from the RDS APIs provide.

Next, consider the second obstacle where multiple resources must be created to produce a usable RDS database. One solution to this obstacle is to just document all the resources that must be created to produce something that can be used. This solution is laborious, error-prone, and is generally a poor developer experience.

Fortunately, there is an alternative solution that abstracts away the complexities of creating instances that are known to work well with application workloads.

This solution uses the `ClusterInstanceClass` API provided by Services Toolkit. Instance classes allow for logical service instances to be presented to Application Operators, allowing them to discover, reason about, and, most importantly, claim service instances that they can then bind to their application workloads.

The rest of this topic describes how both these solutions can come together to form an end-to-end integration for RDS services on Tanzu Application Platform.

Create an RDS service instance

This section describes how to create an RDS service instance in Tanzu Application Platform by using a ready-made reference Carvel Package. This step is typically performed by the Service Operator role. Follow the steps in Creating an RDS service instance by using a Carvel Package.

Alternatively, if you want to author your own reference package and want to learn about the underlying APIs and how they come together to produce a useable service instance for Tanzu Application Platform, you can achieve the same outcome by using the more advanced Creating an RDS service instance manually.

After you complete either of these steps and have a running RDS service instance, return here to continue with the rest of the use case.

Now that you have created an RDS service instance, you need to grant sufficient RBAC permissions to enable Services Toolkit to read its credentials. For this example, create the following aggregated `ClusterRole` in your EKS cluster:

```
# stk-secret-reader.yaml
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
```

```
  - list
  - watch
```

```
kubectl apply -f stk-secret-reader.yaml
```

Create a service instance class for RDS

Now that you know how to create RDS service instances it's time to learn how to make those instances discoverable to Application Operators. This step is typically performed by the Service Operator role.

You can use Services Toolkit's `ClusterInstanceClass` API to create a service instance class to represent RDS service instances within the cluster. The existence of such classes make these logical service instances discoverable to Application Operators. This allows them to create Resource Claims for such instances and to then bind them to application workloads.

Create the following Kubernetes resource on your EKS cluster:

```
# clusterinstanceclass.yaml
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: aws-rds-postgres
spec:
  description:
    short: AWS RDS instances with a postgresql engine
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: rds-postgres
```

Apply it by running:

```
kubectl apply -f clusterinstanceclass.yaml
```

In this example, the class states that claimable instances of RDS PostgreSQL are represented by `Secret` objects with the label `services.apps.tanzu.vmware.com/class` set to `rds-postgres`. A `Secret` with this label was created in the earlier step when you provisioned an RDS service instance.

Although this example uses `services.apps.tanzu.vmware.com/class`, there is no special meaning to that key. The Service Operator role can choose arbitrary label names and values. They might also decide to select multiple labels or combine a label selector with a field selector when defining the `ClusterInstanceClass`.

If you want to claim resources across namespace boundaries, you must create a corresponding `ResourceClaimPolicy`. For example, if the provisioned RDS PostgreSQL instances exist in the namespace `service-instances`, and you want to allow Application Operators to claim them for workloads residing in the `default` namespace, create the following `ResourceClaimPolicy`:

```
# resourceclaimpolicy.yaml
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
```

```
kind: ResourceClaimPolicy
metadata:
  name: default-can-claim-rds-postgres
  namespace: service-instances
spec:
  subject:
    kind: Secret
    group: ""
    selector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: rds-postgres
  consumingNamespaces: [ "default" ]
```

Apply it by running:

```
kubectl apply -f resourceclaimpolicy.yaml
```

Discover, Claim, and Bind to an RDS

Creating the `ClusterInstanceClass` and the corresponding RBAC informs Application Operators that RDS is available to use with their application workloads on Tanzu Application Platform. In this section you learn how to discover, claim, and bind to the RDS service instance previously created. The Application Operator is typically the role that discovers and claims service instances. The Application Developer is typically the role that handles binding.

To discover what service instances are available to them, Application Operators can run

```
tanzu services classes list

  NAME                   DESCRIPTION
  aws-rds-postgres       AWS RDS instances with a postgresql engine
```

Here you can see information about the `ClusterInstanceClass` created in the earlier step. Each `ClusterInstanceClass` created is added to the list of classes returned here.

The next step is to claim an instance of the wanted class, but to do that, Application Operators must first discover the list of currently claimable instances for the class. Many variables, including namespace boundaries, claim policies, and the exclusivity of claims, affect the capacity to claim instances. Therefore Services Toolkit provides the CLI command `tanzu service claimable list` to help inform Application Operators of the instances that can enable successful claims. Example:

```
tanzu services claimable list --class aws-rds-postgres

  NAME           NAMESPACE  API KIND   API GROUP/VERSION
  rds-bindable   default    Secret     v1
```

Because of the setup performed as part of Creating a claimable class for RDS instances, the secrets created from the `SecretTemplate` as part of Create an RDS service instance now appear as claimable to the Application Operator. From here on it is simply a case of creating a resource claim for the instance and then binding the claim to an application workload.

Create a claim for the newly created secret by running:

```
tanzu service resource-claim create ack-rds-claim \
  --resource-name rds-bindable \
  --resource-kind Secret \
  --resource-api-version v1
```

> **Note**
>
> Create the claim in the same namespace as your workload. If your workload is in a different namespace to the one currently targeted, add the `--namespace` flag to the above command.

Obtain the claim reference of the claim by running:

```
tanzu service resource-claim list -o wide
```

Verify that the output is similar to the following:

```
NAME                    READY   REASON   CLAIM REF
ack-rds-claim           True             services.apps.tanzu.vmware.com/v1alpha1:Resourc
eClaim:ack-rds-claim
```

Create an application workload that consumes the claimed RDS PostgreSQL Database. Example:

```
tanzu apps workload create my-workload \
  --git-repo https://github.com/sample-accelerators/spring-petclinic \
  --git-branch main \
  --git-tag tap-1.2 \
  --type web \
  --label app.kubernetes.io/part-of=spring-petclinic \
  --annotation autoscaling.knative.dev/minScale=1 \
  --env SPRING_PROFILES_ACTIVE=postgres \
  --service-ref db=services.apps.tanzu.vmware.com/v1alpha1:ResourceClaim:ack-rds-claim
```

`--service-ref` is set to the claim reference obtained previously.

Your application workload now starts up and connects automatically to the RDS service instance. You can verify this by visiting the app in the browser and, for example, creating a new owner through the UI.

Prerequisites

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Meet these prerequisites to follow along with Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK).

1. Install the AWS CLI or gain access to the Amazon Cloud Console

2. Gain the AWS privileges required to configure the IAM permissions and identity used by the ACK service controller for RDS

3. Create an Amazon EKS cluster. The quickest and simplest way to create an EKS cluster is to use eksctl, as in this example:

```
eksctl create cluster -r YOUR-REGION -m 6 -M 8 -n YOUR-CLUSTER-NAME --version 1
.22
```

> **Note**
>
> Using an EKS Kubernetes version of 1.23 or above may require extra configuration with TAP. See troubleshooting guide.

4. Tanzu Application Platform v1.2.0 or later and Cluster Essentials v1.2.0 or later have to be installed on the Kubernetes cluster.

   Note: To check if you have an appropriate version, run the following:

   ```
   kubectl api-resources | grep secrettemplate
   ```

   This command returns the `SecretTemplate` API. If it does not for you, verify that Cluster Essentials for VMware Tanzu v1.2.0 or later is installed.

5. Install the ACK service controller for RDS and configure it in the cluster. It is recommended to install the latest stable version of the Operator (v0.0.25 is known to work with this specific use case). For instructions, see Install an ACK Controller. This entails installing the RDS ACK service controller, which entails updating some of the environment variables used throughout the official documentation. In particular, note the following changes:

   - Set the `SERVICE` environment variable to `rds` by running:

     ```
     export SERVICE=rds
     ```

   - Set the `AWS_REGION` environment variable to the AWS region where the RDS instances is created by running:

     ```
     export AWS_REGION=us-east-1
     ```

6. After the operator is installed, configure IAM permissions. Set the following environment variables accordingly:

   - Set the `SERVICE` environment variable to `rds` by running:

     ```
     export SERVICE=rds
     ```

   - Set the `EKS_CLUSTER_NAME` environment variable to the name of your EKS cluster by running:

     ```
     export EKS_CLUSTER_NAME=<YOUR_CLUSTER_NAME>
     ```

   - Set the `AWS_REGION` environment variable to the AWS region where the RDS instances is created by running:

```
export AWS_REGION=us-east-1
```

Configuring the AWS RDS environment

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic tells you how to configure your AWS environment for Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK).

Prerequisites

Meet the prerequisites for consuming AWS RDS on Tanzu Application Platform with AWS Controllers for Kubernetes (ACK), including using `eksctl` to create an EKS cluster. This procedure entails reusing the resources created when you created the cluster.

You can still create separate VPCs, subnets and security groups if you want. Ensure that these are configured such that Tanzu Application Platform workloads on EKS can discover and connect to RDS instances.

Configure the AWS RDS environment

To configure the AWS RDS environment:

1. Use the AWS cloud console to determine the VPC ID of the EKS cluster, or run this command:

   ```
   aws eks describe-cluster --name YOUR-CLUSTER-NAME --region YOUR-REGION | \
     jq -r .cluster.resourcesVpcConfig.vpcId
   ```

   RDS instances must be configured with a subnet group consisting of two or more subnets. The subnets within the subnet group must adhere to the following rules:

   - The subnets must be in different availability zones, such as us-west-1a and us-west-1b.
   - All subnets must either be public or private, which the `MapPublicIpOnLaunch` value reveals.

2. Discover existing subnets within your VPC by using the AWS Cloud console or by running:

   ```
   aws ec2 describe-subnets --filters "Name=vpc-id,Values=YOUR-VPC-ID" --region YO
   UR-REGION | \
     jq -r '.Subnets[] | select(.MapPublicIpOnLaunch == false) | .SubnetId'
   ```

3. Create the following Kubernetes resource on your EKS cluster by using the subnet IDs output:

```
# dbsubnetgroup.yaml
---
apiVersion: rds.services.k8s.aws/v1alpha1
kind: DBSubnetGroup
metadata:
  name: DB-SUBNET-GROUP-NAME
  namespace: ack-system
spec:
  name: DB-SUBNET-GROUP-NAME
  description: rds-subnet-group
  subnetIDs:
  - SUBNET-ID-1
  - SUBNET-ID-2
  - SUBNET-ID-3
```

Where `DB-SUBNET-GROUP-NAME`, `SUBNET-ID-1`, `SUBNET-ID-2`, and `SUBNET-ID-3` are your own values.

4. Run

```
kubectl apply -f dbsubnetgroup.yaml
```

5. Confirm that you created `DBSubnetGroup` by running:

```
kubectl get DBSubnetGroup -n ack-system DB-SUBNET-GROUP-NAME -o yaml
```

6. Identify a suitable security group to use for the RDS instance that allows workloads running on the Tanzu Application Platform cluster to establish a connection. Do so by searching for a suitable security group within the AWS cloud console, or by running the following command, which identifies the `Communication between all nodes in the cluster` security group:

```
aws ec2 describe-security-groups --filters "Name=vpc-id,Values=YOUR-VPC-ID" --r
egion YOUR-REGION | \
  jq -r '.SecurityGroups[] | select(.Description == "Communication between all
nodes in the cluster").GroupId'
```

7. Record `DB-SUBNET-GROUP-NAME` and the security group ID output from the previous command. You need both when creating RDS instances as part of this use case.

Creating AWS RDS Instances manually using kubectl (experimental)

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic is for users who want to understand the underlying APIs involved in making a bindable service instance using `DBInstance` and `SecretTemplate` resources. For a simpler user experience, see Creating an RDS service instance through a Carvel Package.

Prerequisite

Meet the prerequisites in Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK) and keep the following information to hand:

- `DB-SUBNET-GROUP-NAME` - the name of the `DBSubnetGroup` resource previously created
- `SECURITY-GROUP-ID` - the security group ID to use for this RDS instance

Create an RDS service instance by using kubectl

Follow these procedures to create an RDS service instance by using kubectl.

Create the `DBInstance` resource

This example uses secret-gen to generate a `Password` for the `DBInstance`. You can also provide an explicit password through a `Secret`.

1. Create Kubernetes resources on your EKS cluster by using the following example. This YAML creates the `DBInstance` resource in the `default` namespace.

```
# dbinstance.yaml
---
apiVersion: secretgen.k14s.io/v1alpha1
kind: Password
metadata:
 name: rds-psql-password
 namespace: default
spec:
 length: 64
 secretTemplate:
   type: Opaque
   stringData:
     password: $(value) # do not edit, this will auto generate a password.
---
apiVersion: rds.services.k8s.aws/v1alpha1
kind: DBInstance
metadata:
 name: rds-psql-1
 namespace: default
spec:
 allocatedStorage: 20
 dbInstanceClass: db.t3.micro
 dbInstanceIdentifier: rds-psql-1
 dbName: postgres
 engine: postgres
 engineVersion: "14.1"
 masterUsername: adminUser
 masterUserPassword:
   namespace: default
   name: rds-psql-password
   key: password
 vpcSecurityGroupIDs:
 - SECURITY-GROUP-ID                     # modify value
 dbSubnetGroupName: DB-SUBNET-GROUP-NAME # modify value
```

```
 # Note: due to an issue in the RDS ACK controller, it is recommended to explic
itly set the
 # following optional spec fields.
 # default values for the optional fields are provided below.
 # https://github.com/aws-controllers-k8s/community/issues/1346
 autoMinorVersionUpgrade: true
 backupRetentionPeriod: 1
 copyTagsToSnapshot: false
 deletionProtection: false
 licenseModel: postgresql-license
 monitoringInterval: 0
 multiAZ: false
 preferredBackupWindow: 23:00-23:30
 preferredMaintenanceWindow: wed:23:34-thu:00:04
 publiclyAccessible: false
 storageEncrypted: false
 storageType: gp2
```

Where:

- `DB-SUBNET-GROUP-NAME` is the name of the `DBSubnetGroup` resource previously created
- `SECURITY-GROUP-ID` is the security group ID to use for this RDS instance

2. Run:

```
kubectl apply -f dbinstance.yaml
```

3. Verify the creation status of the `DBInstance` by inspecting the conditions in the Kubernetes API. To do so, run:

```
kubectl get DBInstance rds-psql-1 -o yaml -n default
```

Create a Binding Specification Compatible Secret

As mentioned in Creating service instances that are compatible with Tanzu Application Platform, for Tanzu Application Platform workloads to be able to claim and bind to services such as RDS, a resource compatible with Service Binding Specification must exist in the cluster.

This can take the form of either a `ProvisionedService` or a Kubernetes `Secret` with some known keys. Both are defined in the specification.

The RDS `DBInstance` you created does not adhere to `ProvisionedService` and does not create a spec-compatible secret. So, you must create one using the resources you have available.

In this topic, you create a Kubernetes secret in the necessary format using the secret-gen tooling. You do so by using the `SecretTemplate` API to extract values from the `DBInstance` resource and populate a new spec-compatible secret with the values.

Create a ServiceAccount for secret templating

As part of using the `SecretTemplate` API, a Kubernetes `ServiceAccount` must be provided. The `ServiceAccount` is used for reading the `DBInstance` resource and the `Secret` created from the `Password` resource.

1. Create the following Kubernetes resources on your EKS cluster:

```
# secrettemplate-sa.yaml
---
apiVersion: v1
kind: ServiceAccount
metadata:
 name: rds-resources-reader
 namespace: default
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
 name: rds-resources-reading
 namespace: default
rules:
- apiGroups:
 - ""
 resources:
 - secrets
 verbs:
 - get
 - list
 - watch
 resourceNames:
 - rds-psql-password
- apiGroups:
 - rds.services.k8s.aws
 resources:
 - dbinstances
 verbs:
 - get
 - list
 - watch
 resourceNames:
 - rds-psql-1
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
 name: rds-resources-reader-to-read
 namespace: default
roleRef:
 apiGroup: rbac.authorization.k8s.io
 kind: Role
 name: rds-resources-reading
subjects:
 - kind: ServiceAccount
 name: rds-resources-reader
 namespace: default
```

2. Run:

```
kubectl apply -f secrettemplate-sa.yaml
```

Create a SecretTemplate

In combination with the `ServiceAccount` you created, a `SecretTemplate` can be used to declaratively create a secret that is compatible with the service binding specification.

The `.spec.inputResources` fields list the resources with information needed to create the secret. The `.spec.template` field defines how that information is interpolated as a secret.

To specify fields on an input resource, you can use JSONPath syntax that is very similar to kubectl syntax. The only difference is the delimiters, which are `\$(` and `)` instead of `{` and `}`.

For example, `$(.rds.status.endpoint.address)` produces the host address of an RDS instance if the input resource is an ACK controller `DBInstance` resource.

This syntax can currently be used in the following fields of the `SecretTemplate` API:

- `.spec.inputResource[].ref.name` for dynamically loading input resources of the APIs of input resources previously in the list
- `.spec.template` values for taking values from the input resources and interpolating them into the secret you create

In this case, you directly reference the `DBInstance` resource and then dynamically load the secret containing the password from its specification.

You then create a `Secret` conforming to the Postgres auto-configuration for Spring Cloud Bindings to enable a fully automated, end-to-end binding experience for application workloads on Tanzu Application Platform.

1. Create the following Kubernetes resources on your EKS cluster:

```
# bindable-rds-secrettemplate.yaml
---
apiVersion: secretgen.carvel.dev/v1alpha1
kind: SecretTemplate
metadata:
 name: rds-bindable
 namespace: default
spec:
 serviceAccountName: rds-resources-reader
 inputResources:
 - name: rds
   ref:
     apiVersion: rds.services.k8s.aws/v1alpha1
     kind: DBInstance
     name: rds-psql-1
 - name: creds
   ref:
     apiVersion: v1
     kind: Secret
     name: "$(.rds.spec.masterUserPassword.name)"
template:
 metadata:
   labels:
     app.kubernetes.io/component: rds-postgres
     app.kubernetes.io/instance: "$(.rds.metadata.name)"
     services.apps.tanzu.vmware.com/class: rds-postgres
 type: postgresql
 stringData:
   type: postgresql
   port: "$(.rds.status.endpoint.port)"
   database: "$(.rds.spec.dbName)"
   host: "$(.rds.status.endpoint.address)"
```

```
  username: "$(.rds.spec.masterUsername)"
data:
  password: "$(.creds.data.password)"
```

2. Run:

```
kubectl apply -f bindable-rds-secrettemplate.yaml
```

Verify

Find the name of the secret produced by reading the status of `SecretTemplate`. To do so, run:

```
kubectl get secrettemplate -n default rds-bindable -o jsonpath="{.status.secret.name}"
```

Delete an RDS service instance

Delete an RDS service instance by running:

```
kubectl delete DBInstance rds-psql-1 -n default
kubectl delete SecretTemplate rds-bindable -n default
kubectl delete Password rds-psql-password -n default
kubectl delete ServiceAccount rds-resources-reader -n default
kubectl delete RoleBinding rds-resources-reader-to-read -n default
kubectl delete Role rds-resources-reading -n default
```

Summary and Next Steps

You learned how to use Carvel's `SecretTemplate` API to construct a secret that is compatible with the binding specification to create an AWS RDS service instance.

Now that you have this available in the cluster, you can learn how to make use of it by continuing where you left off in Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK).

Creating AWS RDS instances by using a Carvel package (experimental)

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes how to create, update, and delete RDS service instances by using a Carvel package. For a more detailed and low-level alternative procedure, see Creating AWS RDS Instances manually by using kubectl.

Prerequisite

Meet the prerequisites in Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS

Controllers for Kubernetes (ACK).

The package repository and service instance package bundles for this topic are in the tanzu-application-platform-reference-packages GitHub repository.

Create an RDS service instance using a Carvel package

Follow the steps in the following procedures.

Add a reference package repository to the in the cluster

To add a reference package repository to the in the cluster:

1. Use the Tanzu CLI to add the new Service Reference packages repository by running:

```
tanzu package repository add tap-service-reference-packages --url ghcr.io/vmwar
e-tanzu/tanzu-application-platform-reference-packages/tap-service-reference-pac
kage-repo:0.0.1 -n tanzu-package-repo-global
```

2. Use the following example to create a `ServiceAccount` that you use to provision `PackageInstall` resources. The namespace of this `ServiceAccount` must match the namespace of the `tanzu package install` command in the next step.

```
# rds-service-account-installer.yaml
---
apiVersion: v1
kind: ServiceAccount
metadata:
 name: rds-install
 namespace: default
---
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
 name: rds-install
 namespace: default
rules:
- apiGroups: ["*"] # TODO: use more fine-grained RBAC permissions
 resources: ["*"]
 verbs: ["*"]
---
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
 name: rds-install
 namespace: default
subjects:
- kind: ServiceAccount
 name: rds-install
roleRef:
 apiGroup: rbac.authorization.k8s.io
 kind: Role
 name: rds-install
```

3. Run:

```
kubectl apply -f rds-service-account-installer.yaml
```

Create an RDS service instance through the Tanzu CLI

To create an RDS service instance through the Tanzu CLI:

1. Create the following Kubernetes resources on your EKS cluster:

   ```
   # RDS-INSTANCE-NAME-values.yaml
   ---
   name: "RDS-INSTANCE-NAME"
   namespace: "default"
   dbSubnetGroupName: "DB-SUBNET-GROUP-NAME"
   vpcSecurityGroupIDs:
   - "SECURITY-GROUP-ID"
   ```

   Where:

   - `RDS-INSTANCE-NAME` is a chosen name for the RDS instance to create
   - `DB-SUBNET-GROUP-NAME` is the name of the `DBSubnetGroup` resource previously created
   - `SECURITY-GROUP-ID` is the security group ID to use for this RDS instance

2. Use the Tanzu CLI to install an instance of the reference service instance Package by running:

   ```
   tanzu package install RDS-INSTANCE-NAME --package-name psql.aws.references.serv
   ices.apps.tanzu.vmware.com --version 0.0.1-alpha --service-account-name rds-ins
   tall -f RDS-INSTANCE-NAME-values.yaml -n default
   ```

You can install the `psql.aws.references.services.apps.tanzu.vmware.com` package multiple times to produce multiple RDS service instances.

To do so, prepare a separate `RDS-INSTANCE-NAME-values.yaml` file and then install the package with a different name and the earlier mentioned separate data values file for each RDS service instance.

Verify

To verify:

1. Verify the creation status for the RDS instance by inspecting the conditions in the Kubernetes API. To do so, run:

   ```
   kubectl get DBInstance RDS-INSTANCE-NAME -n default -o yaml
   ```

2. Wait for up to 20 minutes.

3. Find the binding-compliant secret that `PackageInstall` produced by running:

   ```
   kubectl get secrettemplate RDS-INSTANCE-NAME-bindable -n default -o jsonpath="{
   .status.secret.name}"
   ```

Delete an RDS service instance

Delete the RDS service instance by running:

```
tanzu package installed delete RDS-INSTANCE-NAME -n default
```

Summary

You learned how to use Carvel's `Package` and `PackageInstall` APIs to create an RDS service instance. To learn more about the pieces that comprise this service instance package, see Create an RDS service instance manually.

Now that you have an RDS service instance in the cluster, you can learn how to make use of it by continuing from where you left off in Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK).

Consuming AWS RDS on Tanzu Application Platform with Crossplane

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Overview

This topic describes how to use Services Toolkit to enable Tanzu Application Platform workloads to consume AWS RDS PostgreSQL databases.

This topic makes use of Crossplane to manage RDS instances in AWS. It is an alternative approach to using the AWS Controllers for Kubernetes (ACK) to achieve the same outcomes.

> **Note**
>
> This usecase is not currently compatible with TAP air-gapped installations.

Prerequisites

Meet these prerequisites:

- Create a Kubernetes cluster that supports running both Tanzu Application Platform and Crossplane
- Install Tanzu Application Platform on the Kubernetes cluster
- Gain access to an AWS account with permissions to manage RDS database instances
- Install AWS CLI
- Configure a named profile for an AWS account that has permissions to manage RDS databases.

Install Crossplane

> **Note**
>
> For the latest steps for installing Crossplane, see these instructions. For the instructions in this topic, it is important to enable support for external secret stores in Crossplane. This is currently an Alpha feature. As such, you will have to explicitly set command line flag `--enable-external-secret-stores` when starting the Crossplane controller.

Run the following commands to install Crossplane to your existing Kubernetes cluster:

```
kubectl create namespace crossplane-system

helm repo add crossplane-stable https://charts.crossplane.io/stable
helm repo update

helm install crossplane --namespace crossplane-system crossplane-stable/crossplane \
  --set 'args={--enable-external-secret-stores}'
```

For this topic, you do not need to install the Crossplane CLI or any additional configuration package.

Install AWS Provider for Crossplane

To install the AWS Provider for Crossplane:

1. Run:

   ```
   kubectl apply -f -<<EOF
   ---
   apiVersion: pkg.crossplane.io/v1
   kind: Provider
   metadata:
    name: provider-aws
   spec:
    package: xpkg.upbound.io/crossplane-contrib/provider-aws:v0.33.0
   EOF
   ```

2. After installing the provider, you see a new `rdsinstances.database.aws.crossplane.io` API resource available in your Kubernetes cluster. See the health of the installed provider by running:

   ```
   kubectl get provider.pkg.crossplane.io provider-aws
   ```

Configure AWS provider

To configure an AWS provider:

1. Ensure you are logged into using the aws cli and can view db instances.

   ```
   AWS_PROFILE=default && aws rds describe-db-instances --region us-east-1 --profi
   le $AWS_PROFILE
   ```

If your AWS profile is not named `default`, change `AWS_PROFILE` to the actual name.

2. Create a new key file:

```
AWS_PROFILE=default && echo -e "[default]\naws_access_key_id = $(aws configure
get aws_access_key_id --profile $AWS_PROFILE)\naws_secret_access_key = $(aws co
nfigure get aws_secret_access_key --profile $AWS_PROFILE)\naws_session_token =
$(aws configure get aws_session_token --profile $AWS_PROFILE)" > creds.conf
```

   If your AWS profile is not named `default`, change `AWS_PROFILE` to the actual name.

3. Verify that you a created a new key file by reading the content of the newly created `creds.conf` file.

4. Create a new secret from the key file by running:

```
kubectl create secret generic aws-provider-creds -n crossplane-system --from-fi
le=creds=./creds.conf
```

5. Delete the key file by running:

```
rm -f creds.conf
```

6. Configure the AWS provider to use the newly created secret by running:

```
kubectl apply -f -<<EOF
---
apiVersion: aws.crossplane.io/v1beta1
kind: ProviderConfig
metadata:
 name: default
spec:
 credentials:
   source: Secret
   secretRef:
     namespace: crossplane-system
     name: aws-provider-creds
     key: creds
EOF
```

Define composite resource types

Now that the AWS provider for Crossplane is installed and configured, you can create a new `CompositeResourceDefinition` (XRD) and corresponding `Composition` representing individual instances of RDS PostgreSQL by following the steps in this section. For more information about these concepts see the Crossplane composition documentation.

Instead of creating your own custom XRD and composition, you can also install an existing Crossplane configuration package for AWS that includes pre-configured XRDs and compositions for RDS.

The primary reason for choosing to create a new XRD and composition is to ensure the connection secrets for newly provisioned RDS PostgreSQL instances support the Service Binding Specification for Kubernetes and automatic Spring Boot configuration using Spring Cloud Bindings.

1. Create a new XRD by running:

```
kubectl apply -f -<<EOF
---
apiVersion: apiextensions.crossplane.io/v1
kind: CompositeResourceDefinition
metadata:
 name: xpostgresqlinstances.bindable.database.example.org
spec:
 claimNames:
   kind: PostgreSQLInstance
   plural: postgresqlinstances
 connectionSecretKeys:
 - type
 - provider
 - host
 - port
 - database
 - username
 - password
 group: bindable.database.example.org
 names:
   kind: XPostgreSQLInstance
   plural: xpostgresqlinstances
 versions:
 - name: v1alpha1
   referenceable: true
   schema:
     openAPIV3Schema:
       properties:
         spec:
           properties:
             parameters:
               properties:
                 storageGB:
                   type: integer
               required:
               - storageGB
               type: object
           required:
           - parameters
           type: object
       type: object
   served: true
EOF
```

After the newly created XRD is reconciled there are two new API resources available in your Kubernetes cluster, `xpostgresqlinstances.bindable.database.example.org` and `postgresqlinstances.bindable.database.example.org`.

2. Create a corresponding composition by running:

```
kubectl apply -f -<<EOF
---
apiVersion: apiextensions.crossplane.io/v1
kind: Composition
metadata:
 labels:
```

```
    provider: "aws"
    vpc: "default"
  name: xpostgresqlinstances.bindable.aws.database.example.org
spec:
  compositeTypeRef:
    apiVersion: bindable.database.example.org/v1alpha1
    kind: XPostgreSQLInstance
  publishConnectionDetailsWithStoreConfigRef:
    name: default
  resources:
  - base:
      apiVersion: database.aws.crossplane.io/v1beta1
      kind: RDSInstance
      spec:
        forProvider:
          dbInstanceClass: db.t2.micro
          engine: postgres
          dbName: postgres
          engineVersion: "12"
          masterUsername: masteruser
          publiclyAccessible: true
          region: us-east-1
          skipFinalSnapshotBeforeDeletion: true
        writeConnectionSecretToRef:
          namespace: crossplane-system
    connectionDetails:
    - name: type
      value: postgresql
    - name: provider
      value: aws
    - name: database
      value: postgres
    - fromConnectionSecretKey: username
    - fromConnectionSecretKey: password
    - name: host
      fromConnectionSecretKey: endpoint
    - fromConnectionSecretKey: port
    name: rdsinstance
    patches:
    - fromFieldPath: metadata.uid
      toFieldPath: spec.writeConnectionSecretToRef.name
      transforms:
      - string:
          fmt: '%s-postgresql'
          type: Format
        type: string
      type: FromCompositeFieldPath
    - fromFieldPath: spec.parameters.storageGB
      toFieldPath: spec.forProvider.allocatedStorage
      type: FromCompositeFieldPath
EOF
```

This composition ensures that all RDS PostgreSQL instances are placed in the `us-east-1` region and use the default VPC for the respective AWS account.

3. Take one of these actions:

    - Connect to those instances from outside the default VPC by assigning an appropriate inbound rule for TCP on port `5432` to the security group of that VPC.

- Define a composition that creates a separate VPC for each RDS PostgreSQL instance and automatically configures inbound rules. See this example.

Provision RDS PostgreSQL instance

As the service operator persona, you now provision an instance of RDS PostgreSQL using the `postgresqlinstances.bindable.database.example.org` API managed by the XRD you previously created.

`.spec.publishConnectionDetailsTo` provides Crossplane with the name and a label for the secret that stores the connection details for the newly created database.

1. Create an RDS database instance in your AWS account by running:

```
kubectl apply -f -<<EOF
---
apiVersion: bindable.database.example.org/v1alpha1
kind: PostgreSQLInstance
metadata:
 name: rds-postgres-db
 namespace: default
spec:
 parameters:
   storageGB: 20
 compositionSelector:
   matchLabels:
     provider: aws
     vpc: default
 publishConnectionDetailsTo:
   name: rds-postgres-db
   metadata:
     labels:
       services.apps.tanzu.vmware.com/class: rds-postgres
EOF
```

Caution

If you are planning to create this resource using Namespace Provisioner, then you must take steps to prevent the Namespace Provisioner from overwriting changes that get written to the `PostgreSQLInstance` resource by Crossplane as part of its reconciliation loop. One way of achieving that is to append the following kapp Config rebaseRules to the same file as the `PostgreSQLInstance` in your gitops repository. For example, the following Config rebase rules will prevent Namespace Provisioner from overwriting Crossplane's updates to the .spec field.

```
---
apiVersion: kapp.k14s.io/v1alpha1
kind: Config
rebaseRules:
- path: [spec]
 type: copy
```

```
sources: [existing]
resourceMatchers:
 - apiVersionKindMatcher: {apiVersion: bindable.database.example.org/v1alpha1,
kind: PostgreSQLInstance}
```

This additional configuration is not required if you create the PostgreSQLInstance manually.

2. Verify that you created the RDS database instance by running:

```
aws rds describe-db-instances --region us-east-1 --profile default
```

Expect the status of the newly created `PostgreSQLInstance` resource to be `READY=True`. This might take a few minutes. You can wait for this by running:

```
kubectl wait --for=condition=Ready=true postgresqlinstances.bindable.database.e
xample.org rds-postgres-db
```

As soon as the RDS PostgreSQL instance is ready, it is claimable by the application operator persona as shown in the next sections.

Create an instance class

To make instances of a service easy for application operators to discover and claim, the service operator persona creates a `ClusterInstanceClass`. In this example, the class states that claimable instances of RDS PostgreSQL are represented by secret objects of type `connection.crossplane.io/v1alpha1` with the label `services.apps.tanzu.vmware.com/class` set to `rds-postgres`:

```
kubectl apply -f -<<EOF
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: rds-postgres
spec:
  description:
    short: AWS RDS Postgresql database instances
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: rds-postgres
    fieldSelector: type=connection.crossplane.io/v1alpha1
EOF
```

You can see that the label specified here matches the label defined in the RDS instance created previously.

In addition, grant RBAC permissions to Services Toolkit to enable reading the secrets specified by the class.

```
kubectl apply -f -<<EOF
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
```

```
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
  - list
  - watch
EOF
```

Claim the RDS PostgreSQL instance and connect to it from the Tanzu Application Platform workload

Thanks to the `ClusterInstanceClass` created in the earlier section, application operators can now use the Tanzu CLI to discover and claim secrets representing RDS PostgreSQL instances.

1. Show available classes of service instances by running:

```
tanzu service classes list

NAME            DESCRIPTION
rds-postgres    AWS RDS Postgresql database instances
```

2. Show claimable instances belonging to the RDS PostgreSQL class by running:

```
tanzu services claimable list --class rds-postgres

NAME                NAMESPACE  API KIND  API GROUP/VERSION
rds-postgres-db     default    Secret    v1
```

3. Create a claim for the discovered secret by running:

Note

Create the claim in the same namespace as your workload. If your workload is in a different namespace to the one currently targeted, add the `--namespace` flag to the above command.

```
tanzu service resource-claim create rds-claim \
--resource-name rds-postgres-db \
--resource-kind Secret \
--resource-api-version v1
```

4. Obtain the claim reference by running:

```
tanzu service resource-claim list -o wide
```

Expect to see the following output:

```
NAME                         READY   REASON   CLAIM REF
rds-claim                    True             services.apps.tanzu.vmware.com/v1alpha1
:ResourceClaim:rds-claim
```

5. Create an application workload that consumes the claimed RDS PostgreSQL database. In this example, `--service-ref` is set to the claim reference obtained earlier.

```
tanzu apps workload create my-workload \
--git-repo https://github.com/sample-accelerators/spring-petclinic \
--git-branch main \
--git-tag tap-1.2 \
--type web \
--label app.kubernetes.io/part-of=spring-petclinic \
--annotation autoscaling.knative.dev/minScale=1 \
--env SPRING_PROFILES_ACTIVE=postgres \
--service-ref db=services.apps.tanzu.vmware.com/v1alpha1:ResourceClaim:rds-clai
m
```

Consuming Azure Flexible Server Tanzu Application Platform

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This section of the documentation covers integrations of Azure Flexible Server into Tanzu Application Platform. Documentation is provided for both an integration using Azure Service Operator (ASO), as well as an integration using Crossplane.

Consuming Azure Flexible Server for PostgreSQL on Tanzu Application Platform with Azure Service Operator (ASO)

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes using Services Toolkit to allow Tanzu Application Platform workloads to consume Azure Flexible Server PostgreSQL. This particular topic makes use of Azure Service Operator v2 to manage PostgreSQL instances in Azure.

Important: This use case is not currently compatible with air-gapped Tanzu Application Platform installations.

Prerequisites

Meet these prerequisites

Create service instances that are compatible with Tanzu Application Platform

To create an Azure PostgreSQL service instance for Tanzu Application Platform to consume, you can use a ready-made, reference Carvel package. The Service Operator typically performs this step. Follow the steps in Creating an Azure PostgreSQL service instance using a Carvel package.

```
$ kubectl api-resources --api-group=dbforpostgresql.azure.com
```

```
NAME                                SHORTNAMES   APIVERSION
  NAMESPACED   KIND
flexibleservers                                  dbforpostgresql.azure.com/v1beta20210601
  true         FlexibleServer
flexibleserversconfigurations                    dbforpostgresql.azure.com/v1beta20210601
  true         FlexibleServersConfiguration
flexibleserversdatabases                         dbforpostgresql.azure.com/v1beta20210601
  true         FlexibleServersDatabase
flexibleserversfirewallrules                     dbforpostgresql.azure.com/v1beta20210601
  true         FlexibleServersFirewallRule
```

There is also the Resource Group, which is in another API group.

```
$ kubectl api-resources --api-group=resources.azure.com
```

```
NAME             SHORTNAMES   APIVERSION                           NAMESPACED   KIND
resourcegroups                resources.azure.com/v1beta20200601   true         Resour
ceGroup
```

To create an Azure PostgreSQL service instance for Tanzu Application Platform to consume, you can use a ready-made, reference Carvel package. The Service Operator typically performs this step. Follow the steps in Creating an Azure PostgreSQL service instance using a Carvel package.

Alternatively, if you are interested in authoring your own reference package and want to learn about the underlying APIs and how they come together to produce a useable service instance for Tanzu Application Platform, you can achieve the same outcome by using the more advanced Creating an Azure PostgreSQL service instance manually topic.

After creating a running Azure PostgreSQL service instance, return here to continue the use case.

Create a service instance class for PSQL

After creating Flexible Server service instances, you must make it possible for application operators to discover them. The service operator role typically performs this step.

You can use Services Toolkit's `ClusterInstanceClass` API to create a service instance class that represents psql service instances within the cluster. The existence of such classes enables application operators to discover logical service instances. This, in turn, enables application operators to create Resource Claims for such instances and to then bind them to application workloads.

Create the following Kubernetes resource on your AKS cluster by running:

```
cat <<EOF | kubectl apply -f -
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: azure-postgres
spec:
  description:
    short: Azure Flexible Server instances with a postgresql engine
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: azure-postgres
EOF
```

In this particular example, the class represents claimable instances of PostgreSQL by a `Secret` object with the label `services.apps.tanzu.vmware.com/class` set to `azure-postgres`.

In addition, you must grant RBAC permissions to Services Toolkit for reading the secrets that the class specifies. Create the following RBAC on your AKS cluster by running:

```
cat <<EOF | kubectl apply -f -
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
  - list
  - watch
EOF
```

To claim resources across namespace boundaries, create a corresponding `ResourceClaimPolicy`.

For example, if the provisioned Azure Flexible Server instance exists in the namespace `service-instances`, and you want to allow application operators to claim them for workloads residing in the `default` namespace, you must create the following `ResourceClaimPolicy` by running:

```
cat <<EOF | kubectl apply -f -
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ResourceClaimPolicy
metadata:
  name: default-can-claim-azure-postgres
  namespace: service-instances
spec:
  subject:
    kind: Secret
```

```
    group: ""
    selector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: azure-postgres
  consumingNamespaces: [ "default" ]
EOF
```

Discover, Claim, and Bind to a PostgreSQL

Creating the `ClusterInstanceClass` and the corresponding RBAC informs application operators that Azure PostgreSQL is available to use with their application workloads on Tanzu Application Platform.

This section describes how to discover, claim, and bind to the PostgreSQL service instance previously created.

Discovering and claiming service instances is typically the responsibility of the application operator role. Binding is typically an action for application developers.

To discover which service instances are available to them, application operators can run:

```
tanzu services classes list

NAME                   DESCRIPTION
azure-postgres         Azure Flexible Server instances with a postgresql engine
```

You can see information about the `ClusterInstanceClass` created in the earlier step. Each `ClusterInstanceClass` created is added to the list of classes.

Next, the application operator claims an instance of the class they want. But to do that the application operator must first discover the list of currently claimable instances for the class.

Many variables affect the capacity to claim instances, including namespace boundaries, claim policies, and the exclusivity of claims. Therefore, Services Toolkit provides the CLI command `tanzu service claimable list` to help inform application operators of the instances that can cause successful claims.

Example:

```
tanzu services claimable list --class azure-postgres

  NAME               NAMESPACE  API KIND  API GROUP/VERSION
  aso-psql-bindable  default    Secret    v1
```

Create a claim for the newly created secret by running:

```
tanzu services claim create aso-psql-claim \
  --resource-name aso-psql-bindable \
  --resource-kind Secret \
  --resource-api-version v1
```

Obtain the claim reference of the claim by running:

```
tanzu services claim list -o wide
```

Verify the output is similar to the following:

```
NAME                    READY  REASON  CLAIM REF
aso-psql-claim          True           services.apps.tanzu.vmware.com/v1alpha1:Resourc
eClaim:aso-psql-claim
```

Test claim With Tanzu Application Platform workload

Create an application workload that consumes the claimed Azure PostgreSQL database by running:

```
tanzu apps workload create my-workload
```

Example:

```
tanzu apps workload create my-workload \
  --git-repo https://github.com/sample-accelerators/spring-petclinic \
  --git-tag tap-1.2 \
  --type web \
  --label app.kubernetes.io/part-of=spring-petclinic \
  --annotation autoscaling.knative.dev/minScale=1 \
  --env SPRING_PROFILES_ACTIVE=postgres \
  --service-ref db=services.apps.tanzu.vmware.com/v1alpha1:ResourceClaim:aso-psql-clai
m
```

`--service-ref` is set to the claim reference obtained previously.

Your application workload starts and connects automatically to the Azure PostgreSQL service instance. You can verify this by visiting the app in the browser and, for example, creating a new owner through the UI.

Delete a PostgreSQL service instance

To delete the Azure PostgreSQL service instance, run the appropriate cleanup commands for how you created the service.

Delete a PostgreSQL service instance by using a Carvel package

```
tanzu package installed delete demo-psql-instance
```

Delete a PostgreSQL service instance by using kubectl

Delete the Azure PostgreSQL service instance by running:

```
kubectl delete flexibleservers.dbforpostgresql.azure.com aso-psql
kubectl delete flexibleserversfirewallrules.dbforpostgresql.azure.com aso-psql
kubectl delete flexibleserversdatabases.dbforpostgresql.azure.com aso-psql
kubectl delete SecretTemplate aso-psql-bindable
kubectl delete Password aso-psql
kubectl delete ServiceAccount aso-psql-reader
kubectl delete RoleBinding aso-psql-reader-to-read
kubectl delete Role aso-psql-reading
```

Troubleshooting Azure Service Operator

Azure Service Operator is still in beta and doesn't always behave as expected. For help with most common scenarios, see Troubleshooting.

Prerequisites

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

To follow the procedures in Consuming Azure Flexible Server for PostgreSQL on Tanzu Application Platform with Azure Service Operator (ASO) you need:

- An Azure AKS Kubernetes cluster
  - This cluster should have a Paid SKU tier. Using the Free tier may cause resource limitation issues.
- Tanzu Application Platform v1.2.0 or later
- Azure Service Operator (ASO) installed on the cluster

If you do not already have a cluster that meets these requirements, you can follow this procedure to create and configure a cluster:

1. Install the Azure CLI. For how to do so, see the Microsoft documentation.
2. Ensure that you are logged in to Azure by running:

   ```
   az login
   ```

3. Create an Azure Kubernetes Service (AKS) cluster. The quickest and simplest way to create an AKS cluster is to use the Azure CLI, as in the following example that creates a new ResourceGroup and AKS cluster:

   ```
   # Name of the resource group to contain the AKS cluster
   RESOURCE_GROUP_NAME=tap-psql-demo

   # Location of the Cluster
   LOCATION=centralus

   # Cluster name
   CLUSTER_NAME=tap-psql-demo-cluster

   # Arbitrary labels for the cluster
   LABELS="key=value key2=value2"

   # Number of k8s nodes
   NODES=2

   az group create --name "${RESOURCE_GROUP_NAME}" --location "${LOCATION}"

   az aks create -g "${RESOURCE_GROUP_NAME}" -n "${CLUSTER_NAME}" --enable-managed
   -identity --node-count "${NODES}" --enable-addons monitoring --tags "${LABELS}"
    -s Standard_DS3_v2 --generate-ssh-keys  --uptime-sla
   ```

```
az aks get-credentials --resource-group "${RESOURCE_GROUP_NAME}" --name "${CLUS
TER_NAME}"
```

> **Note**
>
> This creates an AKS cluster with a paid tier using the `--uptime-sla` flag. Not setting this flag will cause the Kubernetes Control plane to potentially have resource limitation issues. See https://learn.microsoft.com/en-us/azure/aks/quotas-skus-regions#service-quotas-and-limits

For more information about AKS, see the Microsoft documentation.

4. Install Tanzu Application Platform v1.2.0 or later and Cluster Essentials v1.2.0 or later on the Kubernetes cluster. For more information, see Installing Tanzu Application Platform

5. Verify that you have the appropriate versions by running:

```
kubectl api-resources | grep secrettemplate
```

This command returns the `SecretTemplate` API. If it does not work for you, you might not have Cluster Essentials for VMware Tanzu v1.2.0 or later installed.

6. Install the Azure Service Operator (ASO) and configure it in the cluster. You must have the appropriate permission in Azure to create a service principal and configure Azure access. v2.0.0-beta.2 is known to work with this use case. Install the latest stable version of the operator by running:

```
AZURE_TENANT_ID=$(az account show | jq -r '.tenantId')
AZURE_SUBSCRIPTION_ID=$(az account show | jq -r '.id')

az ad sp create-for-rbac -n tap-azure-service-operator --role contributor \
--scopes /subscriptions/"${AZURE_SUBSCRIPTION_ID}" > /tmp/aso-creds.json

AZURE_CLIENT_ID=$(cat /tmp/aso-creds.json | jq -r '.appId')
AZURE_CLIENT_SECRET=$(cat /tmp/aso-creds.json | jq -r '.password' )

rm -f  /tmp/aso-creds.json

# requires carvel kapp v0.46+
kapp deploy -a aso -f https://github.com/Azure/azure-service-operator/releases/
download/v2.0.0-beta.2/azureserviceoperator_v2.0.0-beta.2.yaml -y --wait=false

cat <<EOF | kubectl apply -f -
apiVersion: v1
kind: Secret
metadata:
  name: aso-controller-settings
  namespace: azureserviceoperator-system
stringData:
  AZURE_SUBSCRIPTION_ID: "${AZURE_SUBSCRIPTION_ID}"
  AZURE_TENANT_ID: "${AZURE_TENANT_ID}"
  AZURE_CLIENT_ID: "${AZURE_CLIENT_ID}"
  AZURE_CLIENT_SECRET: "${AZURE_CLIENT_SECRET}"
EOF
```

```
kubectl wait deployment -n azureserviceoperator-system -l app=azure-service-ope
rator-v2 --for=condition=Available=True
```

Next Steps

See Consuming Azure Flexible Server for PostgreSQL on Tanzu Application Platform with Azure Service Operator (ASO).

Creating Azure PostgreSQL Instances manually using kubectl (experimental)

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes how to use Services Toolkit to allow Tanzu Application Platform workloads to consume Azure Flexible Server PostgreSQL. This particular topic makes use of Azure Service Operator v2 to manage PostgreSQL instances in Azure.

Create a resource group

First of all, a ResourceGroup for all PSQL Instances to reside in will be created:

```
cat <<EOF | kubectl apply -f -
---
apiVersion: resources.azure.com/v1beta20200601
kind: ResourceGroup
metadata:
  name: aso-psql
spec:
  location: centralus
EOF
```

Create a Flexible Server service instance

Next, you will create a Flexible Server PSQL Instance, a Database and a Firewall Rule in Azure as well as a Secret for credentials. In this guide you will leverage the `Password` API from Carvel's secretgen controller, which will create the `Secrets` for you. However, any other mechanism to manage those secrets works too.

Change the `.spec.azureName` of the `FlexibleServer` resource below from "aso-psql" to something unique, using only lowercase letters, digits and hyphens. This avoids naming conflicts as Azure has a global naming namespace and this resource may already exist.

```
cat <<'EOF' | kubectl apply -f -
---
apiVersion: secretgen.k14s.io/v1alpha1
kind: Password
```

```
metadata:
  name: aso-psql
spec:
  length: 64
  secretTemplate:
    type: Opaque
    stringData:
      password: $(value)
---
apiVersion: dbforpostgresql.azure.com/v1beta20210601
kind: FlexibleServersDatabase
metadata:
  name: aso-psql
spec:
  azureName: mydb
  owner:
    name: aso-psql
  charset: utf8
---
apiVersion: dbforpostgresql.azure.com/v1beta20210601
kind: FlexibleServersFirewallRule
metadata:
  name: aso-psql
spec:
  owner:
    name: aso-psql
  startIpAddress: 0.0.0.0 #! only allow traffic from azure. See https://docs.microsoft
.com/en-us/azure/postgresql/single-server/concepts-firewall-rules#connecting-from-azur
e. Warning not for production use.
  endIpAddress: 0.0.0.0
---
apiVersion: dbforpostgresql.azure.com/v1beta20210601
kind: FlexibleServer
metadata:
  name: aso-psql
spec:
  location: centralus
  azureName: aso-psql #! CHANGE THIS NAME
  owner:
    name: aso-psql #! the ResourceGroup above
  version: "13" #! only 11,12,13 supported
  sku:
    name: Standard_D4s_v3
    tier: GeneralPurpose
  administratorLogin: myAdmin
  administratorLoginPassword:
    name: aso-psql
    key: password
  storage:
    storageSizeGB: 128
EOF
```

Create a Binding Specification Compatible Secret

As mentioned in Creating service instances that are compatible with Tanzu Application Platform, in order for Tanzu Application Platform workloads to be able to claim and bind to services such as Azure PostgreSQL, a resource compatible with Service Binding Specification must exist in the cluster. This can take the form of either a `ProvisionedService`, as defined by the specification, or a

Kubernetes `Secret` with some known keys, also as defined in the specification.

In this guide, you create a Kubernetes secret in the necessary format using the secretgen-controller tooling. You do so by using the `SecretTemplate` API to extract values from the Azure Service Operator resources and populate a new spec-compatible secret with the values.

Create a ServiceAccount for Secret Templating

As part of using the `SecretTemplate` API, a Kubernetes `ServiceAccount` must be provided. The `ServiceAccount` is used for reading the `FlexibleServer` resource and the `Secret` created from the `Password` resource above.

Create the following Kubernetes resources on your AKS cluster:

```
cat <<EOF | kubectl apply -f -
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: aso-psql-reader
  namespace: default
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: aso-psql-reading
  namespace: default
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
  - list
  - watch
  resourceNames:
  - aso-psql
- apiGroups:
  - dbforpostgresql.azure.com
  resources:
  - flexibleservers
  - flexibleserversdatabases
  verbs:
  - get
  - list
  - watch
  resourceNames:
  - aso-psql
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: aso-psql-reader-to-read
  namespace: default
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
```

```
  name: aso-psql-reading
subjects:
- kind: ServiceAccount
  name: aso-psql-reader
  namespace: default
EOF
```

Create a SecretTemplate

In combination with the `ServiceAccount` just created, a `SecretTemplate` can be used to declaratively create a secret that is compatible with the service binding specification. For more information on this API see the Secret Template Documentation.

Create the following Kubernetes resources on your AKS cluster:

```
cat <<'EOF' | kubectl apply -f -
---
apiVersion: secretgen.carvel.dev/v1alpha1
kind: SecretTemplate
metadata:
  name: aso-psql-bindable
  namespace: default
spec:
  serviceAccountName: aso-psql-reader
  inputResources:
  - name: server
    ref:
      apiVersion: dbforpostgresql.azure.com/v1alpha1api20210601
      kind: FlexibleServer
      name: aso-psql
  - name: db
    ref:
      apiVersion: dbforpostgresql.azure.com/v1alpha1api20210601
      kind: FlexibleServersDatabase
      name: aso-psql
  - name: creds
    ref:
      apiVersion: v1
      kind: Secret
      name: "$(.server.spec.administratorLoginPassword.name)"
  template:
    metadata:
      labels:
        app.kubernetes.io/component: aso-psql
        app.kubernetes.io/instance: "$(.server.metadata.name)"
        services.apps.tanzu.vmware.com/class: azure-postgres
    type: postgresql
    stringData:
      type: postgresql
      port: "5432"
      database: "$(.db.status.name)"
      host: "$(.server.status.fullyQualifiedDomainName)"
      username: "$(.server.status.administratorLogin)"
    data:
      password: "$(.creds.data.password)"
EOF
```

Verify the Service Instance

Firstly wait until the PostgreSQL instance is ready. This may take 5 to 10 minutes.

```
kubectl wait flexibleservers.dbforpostgresql.azure.com aso-psql -n default --for=condi
tion=Ready --timeout=5m
```

Next, ensure a bindable `Secret` was produced by the `SecretTemplate`. To do so, run:

```
kubectl wait SecretTemplate -n default aso-psql-bindable --for=condition=ReconcileSucc
eeded --timeout=5m

kubectl get Secret -n default aso-psql-bindable
```

Creating Azure PostgreSQL instances by using a Carvel package (experimental)

Note

Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes creating, updating, and deleting Azure PostgreSQL service instances using a Carvel package. For a more detailed and low-level alternative procedure, see Creating Service Instances that are compatible with Tanzu Application Platform.

Prerequisite

Meet the prerequisites:

The Package Repository and service instance Package Bundles for this guide can be found in the Reference Service Packages GitHub repository.

Create an Azure PostgreSQL service instance using a Carvel package

Follow the steps in the following procedures.

Add a reference package repository to the cluster

The namespace `tanzu-package-repo-global` has a special significance. The kapp-controller defines a Global Packaging namespace. In this namespace, any package the is made available through a Package Respository, is available in every namespace.

When the kapp-controller is installed via Tanzu Application Platform, the namespace is `tanzu-package-repo-global`. If you install the controller in another way, verify which namespace is considered the Global Packaging namespace.

To add a reference package repository to the cluster:

1. Use the Tanzu CLI to add the new Service Reference packages repository:

```
tanzu package repository add tap-reference-service-packages \
    --url ghcr.io/vmware-tanzu/tanzu-application-platform-reference-service-pac
kages:0.0.3 \
    -n tanzu-package-repo-global
```

2. Create a `ServiceAccount` to provision `PackageInstall` resources by using the following example. The namespace of this `ServiceAccount` must match the namespace of the `tanzu package install` command in the next step.

```
kubectl apply -f - <<'EOF'
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: psql-install
---
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: psql-install
rules:
- apiGroups: ["dbforpostgresql.azure.com"]
  resources: ["flexibleservers","flexibleserversdatabases","flexibleserversfire
wallrules"]
  verbs:     ["*"]
- apiGroups: ["resources.azure.com"]
  resources: ["resourcegroups"]
  verbs:     ["*"]
- apiGroups: ["secretgen.carvel.dev", "secretgen.k14s.io"]
  resources: ["secrettemplates","passwords"]
  verbs:     ["*"]
- apiGroups: [""]
  resources: ["serviceaccounts","configmaps"]
  verbs:     ["*"]
- apiGroups: [""]
  resources: ["namespaces"]
  verbs:     ["get", "list"]
- apiGroups: ["rbac.authorization.k8s.io"]
  resources: ["roles","rolebindings"]
  verbs:     ["*"]
---
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: psql-install
subjects:
- kind: ServiceAccount
  name: psql-install
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: psql-install
```

Create a Azure PostgreSQL service instance through the Tanzu CLI

Before you create the values file, here are some values highlighted.

- **aso_controller_namespace**: the Azure Service Operator has some potential conflicting behaviors with the kapp-controller. We reduce the conflicts by annotating the resources with the ASO installation namespace.
- **firewall_rules**: by default, the FlexibleServer is not accessible. Setting `0.0.0.0` as the start and end IP addresses for a firewall rule makes the server available from within Azure.
- **resource_group.use_existing**: if you cannot create a Resource Group in Azure or have other reasons for using an existing one, set this to `true`. Else, the package makes a Resource Group with the name specified by the `resource_group.name` value.

The `server.name` field will be used for the FlexibleServer resource name on Azure, otherwise `name` will be used. It is recommended to set the value of the `name` (and the optional `server.name`) field below from `aso-psql` to something unique, using only lowercase letters, digits and hyphens. This avoids naming conflicts, as Azure has a global naming namespace for FlexibleServer instances and this resource may already exist. Do make sure you also change the commands below using a `aso-psql` value, such as the `aso-psql-bindable` from the SecretTemplate,and replace `aso-psql` with the actual `name`.

1. Create a file holding the configuration of the Azure PostgreSQL service instance:

```
cat <<'EOF' > aso-psql-instance-values.yml
---
name: aso-psql
namespace: service-instances
location: westeurope
aso_controller_namespace: azureserviceoperator-system
create_namespace: false

server:
    administrator_name: trpadmin

database:
    name: testdb

firewall_rules:
    - startIpAddress: 0.0.0.0
      endIpAddress: 0.0.0.0

resource_group:
    use_existing: false
    name: aso-psql
EOF
```

> **Note**
>
> : To understand which settings are available for this package you can run:
>
> ```
> tanzu package available get \
>   --values-schema \
>   psql.azure.references.services.apps.tanzu.vmware.com/0.0.1-alpha
> ```
>
> This shows a list of all configuration options you can use in the `aso-psql-`

`instance-values.yml` file.

2. Use the Tanzu CLI to install an instance of the reference service instance Package.

```
tanzu package install aso-psql-instance \
   --package-name psql.azure.references.services.apps.tanzu.vmware.com \
   --version 0.0.1-alpha \
   --service-account-name psql-install \
   --values-file aso-psql-instance-values.yml \
   --wait
```

You can install the `psql.azure.references.services.apps.tanzu.vmware.com` package multiple times to produce various Azure PostgreSQL Service instances. You create a separate `<INSTANCE-NAME>-values.yml` for each instance, set a different `name` value, and then install the package with the instance-specific data values file.

Verify the Azure Resources

1. Verify the creation status for the Azure PostgreSQL instance by inspecting the conditions in the Kubernetes API. To do so, run:

```
kubectl get flexibleservers.dbforpostgresql.azure.com aso-psql -o yaml
```

2. After some time has passed, sometimes up to 10 minutes, you can find the binding-compliant secret produced by `PackageInstall`. To do so, run:

```
kubectl get secrettemplate aso-psql-bindable -o jsonpath="{.status.secret.name}
"
```

Verify the Service Instance

Firstly wait until the PostgreSQL instance is ready. This may take 5 to 10 minutes.

```
kubectl wait flexibleservers.dbforpostgresql.azure.com aso-psql -n default --for=condi
tion=Ready --timeout=5m
```

Next, ensure a bindable `Secret` was produced by the `SecretTemplate`. To do so, run:

```
kubectl wait SecretTemplate -n default aso-psql-bindable --for=condition=ReconcileSucc
eeded --timeout=5m

kubectl get Secret -n default aso-psql-bindable
```

Summary

You have learnt to use Carvel's `Package` and `PackageInstall` APIs to create a Azure PostgreSQL service instance. If you want to learn more about the pieces that comprise this service instance package, see Creating Azure PostgreSQL Instances manually using kubectl.

Now that you have this available in the cluster, you can learn how to make use of it by continuing where you left off in Consuming Azure PostgreSQL on Tanzu Application Platform (TAP) with ASO.

Azure Service Operator Troubleshooting

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Increase Log Level

There is a guide on the Azure Service Operator (ASO) controller for aiding you in diagnosing problems.

We recommend temporarily change the Controller's binary log level from `v=2` to `v=6`. Setting it higher than six prints a lot more things, such as the HTTP requests with headers, and usually doesn't add more value.

```
kubectl edit deploy -n azureserviceoperator-system azureserviceoperator-controller-man
ager
```

```
spec:
  template:
    spec:
      containers:
      - name: manager
        args:
        - --metrics-addr=0.0.0.0:8080
        - --health-addr=:8081
        - --enable-leader-election
        - --v=6
```

Not Updating The Kubernetes Resources

The ASO controller sometimes conflicts when updating the resource status in Kubernetes. The resource in Azure exists, but is not reflected properly in its corresponding Kubernetes resource.

In the logs you will see a `409 conflict` message when updating the Kubernetes resource. To resolve this, you can restart the Pod, which will take a few seconds.

```
kubectl -n azureserviceoperator-system rollout restart deployment azureserviceoperator
-controller-manager
```

Consuming Azure Flexible Server for PostgreSQL on Tanzu Application Platform with Crossplane

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Introduction

This topic demonstrates how to use Services Toolkit to allow Tanzu Application Platform workloads to consume Azure Flexible Server for PostgreSQL. This particular topic makes use of Crossplane to manage those Flexible Server for PostgreSQL instances. As such, it can be thought of as an alternative approach to Consuming Azure Flexible Server for PostgreSQL on Tanzu Application Platform with Azure Service Operator (ASO) to achieve the similar outcomes.

Note This usecase is not currently compatible with TAP air-gapped installations.

Prerequisites

Meet these prerequisites:

- Install Azure CLI
- Create an AKS cluster
- Install Tanzu Application Platform (v1.2.0 or later) and Cluster Essentials (v1.2.0 or later)

> **Note**
>
> In this example we use an AKS Cluster to deploy Crossplane and Tanzu Application Platform too. However, any other cluster which supports running those two systems should suffice.

Install Crossplane

> **Note**
>
> For the latest steps for installing Crossplane, see these instructions. For the instructions in this topic, it is important to enable support for external secret stores in Crossplane. This is currently an Alpha feature. As such, you will have to explicitly set command line flag `--enable-external-secret-stores` when starting the Crossplane controller.

Run the following commands to install Crossplane to your existing Kubernetes cluster:

```
kubectl create namespace crossplane-system

helm repo add crossplane-stable https://charts.crossplane.io/stable
helm repo update

helm install crossplane --namespace crossplane-system crossplane-stable/crossplane \
  --set 'args={--enable-external-secret-stores}'
```

For this topic, you do not need to install the Crossplane CLI or any additional configuration package.

Install the Azure Provider for Crossplane

To install the Azure Provider for Crossplane, run:

```
kubectl apply -f - <<'EOF'
apiVersion: pkg.crossplane.io/v1alpha1
kind: ControllerConfig
metadata:
  name: jet-azure-config
spec:
  image: crossplane/provider-jet-azure-controller:v0.12.0
  args: ["-d"]
---
apiVersion: pkg.crossplane.io/v1
kind: Provider
metadata:
  name: provider-jet-azure
spec:
  package: crossplane/provider-jet-azure:v0.12.0
  controllerConfigRef:
    name: jet-azure-config
EOF
```

After you have installed the provider, you see a new `flexibleservers.dbforpostgresql.azure.jet.crossplane.io` API resource available in your Kubernetes cluster. You can wait for the provider to become healthy by running:

```
kubectl -n crossplane-system wait provider/provider-jet-azure \
  --for=condition=Healthy=True --timeout=3m
```

Install the Kubernetes Provider for Crossplane

To install the Kubernetes Provider for Crossplane, run:

```
kubectl apply -f - <<'EOF'
apiVersion: pkg.crossplane.io/v1
kind: Provider
metadata:
  name: provider-kubernetes
spec:
  package: "crossplane/provider-kubernetes:main"
EOF
```

Configure the Azure Provider

This section creates a new Service Principal to be used by the Crossplane system to allow it to manage PostgreSQL Servers.

1. Setup some configuration in the current shell session

   ```
   # Set the name of the Service Principal to be created
   AZURE_SP_NAME='sql-crossplane-demo'

   # Get the subscription ID
   AZURE_SUBSCRIPTION_ID="$( az account show -o json | jq -r '.id' )"
   ```

2. Create a new Service Principal and set up the kubernetes secret

```
kubectl create secret generic jet-azure-creds -o yaml --dry-run=client --from-l
iteral=creds="$(
 az ad sp create-for-rbac -n "${AZURE_SP_NAME}" \
   --sdk-auth \
   --role "Contributor" \
   --scopes "/subscriptions/${AZURE_SUBSCRIPTION_ID}" \
   -o json
)" | kubectl apply -n crossplane-system -f -
```

Note

You'll see the following warning:

`WARNING: Option '--sdk-auth' has been deprecated and will be removed in a future release.`

which you can ignore for now. There is some context about that in this issue for the Azure CLI and this issue for the Crossplane Azure Provider.

3. Deploy a `ProviderConfig` which uses the previously created secret for the Azure crossplane provider

```
kubectl apply -f - <<'EOF'
apiVersion: azure.jet.crossplane.io/v1alpha1
kind: ProviderConfig
metadata:
 name: default
spec:
 credentials:
   source: Secret
   secretRef:
     namespace: crossplane-system
     name: jet-azure-creds
     key: creds
EOF
```

Configure the Kubernetes Provider

```
SA=$(kubectl -n crossplane-system get sa -o name | grep provider-kubernetes | sed -e '
s|serviceaccount\/|crossplane-system:|g')
kubectl create role -n crossplane-system password-manager --resource=passwords.secretg
en.k14s.io --verb=create,get,update,delete
kubectl create rolebinding -n crossplane-system provider-kubernetes-password-manager -
-role password-manager --serviceaccount="${SA}"

kubectl apply -f - <<'EOF'
apiVersion: kubernetes.crossplane.io/v1alpha1
kind: ProviderConfig
metadata:
  name: default
spec:
  credentials:
```

```
    source: InjectedIdentity
EOF
```

Define Composite Resource Types

Now that the Azure Provider for Crossplane has been installed and configured, create a new `CompositeResourceDefinition` (XRD) and corresponding `Composition` representing individual instances of Azure PostgreSQL Server. For more information about these concepts see the Crossplane Composition documentation.

1. Create a new XRD by running:

```
kubectl apply -f - <<'EOF'
apiVersion: apiextensions.crossplane.io/v1
kind: CompositeResourceDefinition
metadata:
 name: xpostgresqlinstances.bindable.database.example.org
spec:
 claimNames:
   kind: PostgreSQLInstance
   plural: postgresqlinstances
 connectionSecretKeys:
 - type
 - provider
 - host
 - port
 - database
 - username
 - password
 group: bindable.database.example.org
 names:
   kind: XPostgreSQLInstance
   plural: xpostgresqlinstances
 versions:
 - name: v1alpha1
   referenceable: true
   schema:
     openAPIV3Schema:
       properties:
         spec:
           properties:
             parameters:
               properties:
                 storageGB:
                   type: integer
               required:
               - storageGB
               type: object
           required:
           - parameters
           type: object
       type: object
   served: true
EOF
```

After the newly created XRD has been successfully reconciled, there are two new API resources available in your Kubernetes cluster,

`xpostgresqlinstances.bindable.database.example.org` and
`postgresqlinstances.bindable.database.example.org`.

2. Create a corresponding composition (not in a production environment) by running:

```
kubectl apply -f - <<'EOF'
apiVersion: apiextensions.crossplane.io/v1
kind: Composition
metadata:
  labels:
    provider: azure
  name: xpostgresqlinstances.bindable.gcp.database.example.org
spec:
  compositeTypeRef:
    apiVersion: bindable.database.example.org/v1alpha1
    kind: XPostgreSQLInstance
  publishConnectionDetailsWithStoreConfigRef:
    name: default
  resources:
  - name: dbinstance
    base:
      apiVersion: dbforpostgresql.azure.jet.crossplane.io/v1alpha2
      kind: FlexibleServer
      spec:
        forProvider:
          administratorLogin: myPgAdmin
          administratorPasswordSecretRef:
            name: ""
            namespace: crossplane-system
            key: password
          location: westeurope
          skuName: GP_Standard_D2s_v3
          version: "12" #! 11,12 and 13 are supported
          resourceGroupName: tap-psql-demo
        writeConnectionSecretToRef:
          namespace: crossplane-system
    connectionDetails:
    - name: type
      value: postgresql
    - name: provider
      value: azure
    - name: database
      value: postgres
    - name: username
      fromFieldPath: spec.forProvider.administratorLogin
    - name: password
      fromConnectionSecretKey: "attribute.administrator_password"
    - name: host
      fromFieldPath: status.atProvider.fqdn
    - name: port
      type: FromValue
      value: "5432"
    patches:
    - fromFieldPath: metadata.uid
      toFieldPath: spec.writeConnectionSecretToRef.name
      transforms:
      - string:
          fmt: '%s-postgresql'
          type: Format
```

```
          type: string
        type: FromCompositeFieldPath
      - type: FromCompositeFieldPath
        fromFieldPath: metadata.name
        toFieldPath: spec.forProvider.administratorPasswordSecretRef.name
      - fromFieldPath: spec.parameters.storageGB
        toFieldPath: spec.forProvider.storageMb
        type: FromCompositeFieldPath
        transforms:
        - type: math
          math:
            multiply: 1024
    - name: dbfwrule
      base:
        apiVersion: dbforpostgresql.azure.jet.crossplane.io/v1alpha2
        kind: FlexibleServerFirewallRule
        spec:
          forProvider:
            serverIdSelector:
              matchControllerRef: true
            #! not recommended for production deployments!
            startIpAddress: 0.0.0.0
            endIpAddress: 255.255.255.255
    - name: password
      base:
        apiVersion: kubernetes.crossplane.io/v1alpha1
        kind: Object
        spec:
          forProvider:
            manifest:
              apiVersion: secretgen.k14s.io/v1alpha1
              kind: Password
              metadata:
                name: ""
                namespace: crossplane-system
              spec:
                length: 64
                secretTemplate:
                  type: Opaque
                  stringData:
                    password: $(value)
      patches:
      - type: FromCompositeFieldPath
        fromFieldPath: metadata.name
        toFieldPath: spec.forProvider.manifest.metadata.name
EOF
```

The composition defined above makes sure that all `FlexibleServers` are placed in the `westeurope` region and under the resource group `tap-psql-demo`. This composition fulfils the XRD previously created.

Warning: Setting the `FlexibleServerFirewallRule` to start at `0.0.0.0` and end at `255.255.255.255` will allow access to the PostgreSQL Server from any IP and is not recommended in a production environment.

Create an Instance Class

In order to make instances of a service easily discoverable and claimable by Application Operators, the role of the Service Operator creates a `ClusterInstanceClass`. In this particular example, the class states that claimable instances of PostgreSQL instances are represented by `Secret` objects of type `connection.crossplane.io/v1alpha1` with label `services.apps.tanzu.vmware.com/class` set to `azure-postgres`:

```
kubectl apply -f - <<'EOF'
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: azure-postgres
spec:
  description:
    short: Azure Postgresql database instances
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: azure-postgres
    fieldSelector: type=connection.crossplane.io/v1alpha1
EOF
```

In addition, you need to grant sufficient RBAC permissions to Services Toolkit to be able to read the secrets specified by the class.

```
kubectl apply -f - <<'EOF'
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
  - list
  - watch
EOF
```

Provision Azure Flexible Server for PostgreSQL instances

Playing the role of the Service Operator, you now provision an instance of an Azure Flexible Server for PostgreSQL using the `postgresqlinstances.bindable.database.example.org` API managed by the XRD you previously created. Note that `.spec.publishConnectionDetailsTo` provides Crossplane with the name and a label for the secret that is being used to store the connection details for the newly created database. You can see that the label specified here matches the label selector defined on the `ClusterInstanceClass` you created in the previous step.

The `PostgreSQLInstance` has a dependency on a `Secret` where the Service Operator needs to specify the password for the admin user. Here we use Carvel's `Password` API to create this `Secret` for us.

Run the following command:

```
kubectl apply -f - <<'EOF'
apiVersion: bindable.database.example.org/v1alpha1
kind: PostgreSQLInstance
metadata:
  name: postgresql-server
  namespace: default
spec:
  parameters:
    #! supported storage sizes: 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384,
32768
    storageGB: 32
  compositionSelector:
    matchLabels:
      provider: azure
  publishConnectionDetailsTo:
    name: postgresql-server
    metadata:
      labels:
        services.apps.tanzu.vmware.com/class: azure-postgres
EOF
```

Running this command will cause the creation of a Azure Flexible Server for PostgreSQL instance in your Azure account. You can use the Azure CLI to verify this:

```
az postgres flexible-server list -o table
```

Caution

If you are planning to create this resource using Namespace Provisioner, then you must take steps to prevent the Namespace Provisioner from overwriting changes that get written to the `PostgreSQLInstance` resource by Crossplane as part of its reconciliation loop. One way of achieving that is to append the following kapp Config rebaseRules to the same file as the `PostgreSQLInstance` in your gitops repository. For example, the following Config rebase rules will prevent Namespace Provisioner from overwriting Crossplane's updates to the .spec field.

```
---
apiVersion: kapp.k14s.io/v1alpha1
kind: Config
rebaseRules:
- path: [spec]
  type: copy
  sources: [existing]
  resourceMatchers:
   - apiVersionKindMatcher: {apiVersion: bindable.database.example.org/v1alpha1, kind:
 PostgreSQLInstance}
```

This additional configuration is not required if you create the PostgreSQLInstance manually.

After the instance has been successfully created, the status of the newly created

`PostgreSQLInstance` resource should show `READY=True`. This might take a few minutes. You can wait for this by running:

```
kubectl wait postgresqlinstances.bindable.database.example.org/postgresql-server \
    --for=condition=Ready=true --timeout=10m
```

As soon as the Azure Flexible Server for PostgreSQL instance is ready, it is claimable by the role of the Application Operator as shown in the next section.

Claim the Azure Flexible Server for PostgreSQL Server instance and connect to it from the Tanzu Application Platform Workload

Thanks to the previously created `ClusterInstanceClass`, `Secrets` representing PostgreSQL Server instances can now be discovered and claimed by Application Operators through the Tanzu CLI as shown below.

1. Show available classes of service instances by running:

   ```
   tanzu service classes list

     NAME              DESCRIPTION
     azure-postgres    Azure Postgresql database instances
   ```

2. Show claimable instances belonging to the PostgreSQL Server instance class by running:

   ```
   tanzu services claimable list --class azure-postgres

     NAME                 NAMESPACE  API KIND  API GROUP/VERSION
     postgresql-server    default    Secret    v1
   ```

3. Create a claim for the discovered instance by running:

   > **Note**
   >
   > Create the claim in the same namespace as your workload. If your workload is in a different namespace to the one currently targeted, add the `--namespace` flag to the above command.

   ```
   tanzu service resource-claim create postgresql-server-claim \
     --resource-name postgresql-server\
     --resource-kind Secret \
     --resource-api-version v1
   ```

4. Obtain the claim reference by running:

   ```
   tanzu service resource-claim list -o wide
   ```

   Expect to see the following output:

```
NAME                         READY   REASON   CLAIM REF
postgresql-server-claim      True             services.apps.tanzu.vmware.com/v1alp
ha1:ResourceClaim:postgresql-server-claim
```

5. Create an application workload that consumes the claimed PostgreSQL Server instance by running:

   Example:

```
tanzu apps workload create my-workload \
  --git-repo https://github.com/sample-accelerators/spring-petclinic \
  --git-branch main \
  --git-tag tap-1.2 \
  --type web \
  --label app.kubernetes.io/part-of=spring-petclinic \
  --annotation autoscaling.knative.dev/minScale=1 \
  --env SPRING_PROFILES_ACTIVE=postgres \
  --service-ref db=services.apps.tanzu.vmware.com/v1alpha1:ResourceClaim:postgr
esql-server-claim
```

   Note that `--service-ref` is being set to the claim reference obtained previously.

Consuming Google Cloud SQL on Tanzu Application Platform

Note

Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This section of the documentation covers integrations of Google Cloud SQL into Tanzu Application Platform. Documentation is provided for both an integration using Config Connector, as well as an integration using Crossplane.

Consuming Google Cloud SQL on Tanzu Application Platform (TAP) with Config Connector

Note

Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Introduction

This topic demonstrates how to use Services Toolkit to allow TAP Workloads to consume Google Cloud SQL for PostgreSQL databases. This particular guide makes use of Config Connector to manage PostgreSQL instances in GCP.

This is describing the procedures to produce similar outcomes as in "Consuming AWS RDS on Tanzu Application Platform (TAP) with AWS Controllers for Kubernetes (ACK)". The same points discussed in "Creating Service Instances that are compatible with Tanzu Application Platform" apply here too:

- Neither of the resources discussed below adhere to the Service Binding Specification
- We need to manage the lifecycle of multiple resources which together form a usable database instance

Note Please ensure you have met all prerequisites before reading on.

Note This usecase is not currently compatible with TAP air-gapped installations.

Creating Service Instances that are compatible with Tanzu Application Platform

The installation of the Config Connector Addon results in the availability of new Kubernetes APIs for interacting with Google Cloud resources, specifically Cloud SQL resources, from within the TAP cluster.

```
$ kubectl api-resources --api-group sql.cnrm.cloud.google.com

NAME            SHORTNAMES                          APIVERSION                      NA
MESPACED   KIND
sqldatabases    gcpsqldatabase,gcpsqldatabases   sql.cnrm.cloud.google.com/v1beta1   tr
ue          SQLDatabase
sqlinstances    gcpsqlinstance,gcpsqlinstances   sql.cnrm.cloud.google.com/v1beta1   tr
ue          SQLInstance
sqlsslcerts     gcpsqlsslcert,gcpsqlsslcerts     sql.cnrm.cloud.google.com/v1beta1   tr
ue          SQLSSLCert
sqlusers        gcpsqluser,gcpsqlusers           sql.cnrm.cloud.google.com/v1beta1   tr
ue          SQLUser
```

To create a CloudSQL service instance for consumption by Tanzu Application Platform, you can use a ready-made, reference Carvel Package. This step is typically performed by the role of the Service Operator. Follow the steps in Creating an CloudSQL service instance by using a Carvel Package.

Alternatively, if you are interested in authoring your own Reference Package and want to learn about the underlying APIs and how they come together to produce a useable service instance for Tanzu Application Platform, you can achieve the same outcome by using the more advanced Creating an CloudSQL service instance manually.

Once you have completed either of these steps and have a running CloudSQL service instance, please return here to continue with the rest of the use case.

Creating a Service Instance Class for Cloud SQL

We can now make the Cloud SQL Service Instance discoverable to Application Operators. This step is typically performed by the role of the Service Operator.

You can use Services Toolkit's `ClusterInstanceClass` API to create a "Service Instance Class" to represent Cloud SQL Service Instances within the cluster. The existence of such classes make these logical Service Instances discoverable to Application Operators, thus allowing them to create Resource Claims for such instances and to then bind them to Application Workloads.

Create the following Kubernetes resource::

```
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: cloudsql-postgres
spec:
  description:
    short: Google Cloud SQL with a postgresql engine
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: cloudsql-postgres
```

In this particular example, the class states that claimable instances of Cloud SQL Postgresql are represented by `Secret` objects with label `services.apps.tanzu.vmware.com/class` set to `cloudsql-postgres`. A `Secret` with this label was created earlier when you created the CloudSQL service instance.

Although this example uses `services.apps.tanzu.vmware.com/class`, there is no special meaning to that key. The Service Operator persona can choose arbitrary label names and values. They might also decide to select on multiple labels or combine a label selector with a field selector when defining the `ClusterInstanceClass`.

Now that you have created a `ClusterInstanceClass`, you need to grant sufficient RBAC permissions to enable Services Toolkit to read the resources that match the pool definition of the instance class. For this example, create the following aggregated `ClusterRole` in your cluster:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups: [ "" ]
  resources: [ "secrets" ]
  verbs:     [ "get", "list", "watch" ]
```

If you want to claim resources across namespace boundaries, you will have to create a corresponding `ResourceClaimPolicy`. For example, if the provisioned Cloud SQL instances exist in namespace `service-instances` and you want to allow App Operators to claim them for workloads residing in the `default` namespace, you would have to create the following `ResourceClaimPolicy`:

```
#! optional, when workload and services are in different namespaces
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ResourceClaimPolicy
metadata:
  name: default-can-claim-cloudsql-postgres
  namespace: service-instances
spec:
  subject:
    kind: Secret
    group: ""
    selector:
      matchLabels:
```

```
        services.apps.tanzu.vmware.com/class: cloudsql-postgres
  consumingNamespaces: [ "default" ]
```

Discover, Claim and Bind to a Google Cloud SQL Postgresql Instance

The act of creating the `ClusterInstanceClass` and the corresponding RBAC essentially advertises to Application Operators that Cloud SQL Instances are available to use with their Application Workloads on Tanzu Application Platform. In this step you will learn how to discover, claim and bind to the Cloud SQL Service Instance previously created. Discovery and claiming of Service Instances is typically the role of the Application Operator while binding is typically a step for Application Developers.

To discover what Service Instances are available to them, Application Operators can use the `tanzu services classes list` command.

```
tanzu services classes list

  NAME                      DESCRIPTION
  cloudsql-postgres         Google Cloud SQL with a postgresql engine
```

Here you can see information about the `ClusterInstanceClass` created in the previous step. Each `ClusterInstanceClass` created will be added to the list of classes returned here.

The next step is to “claim” an instance of the desired class, but in order to do that, Application Operators must first discover the list of currently claimable instances for the class. Claimability of instances is affected by many variables (including namespace boundaries, claim policies and the exclusivity of claims) and so Services Toolkit provides a CLI command to help inform Application Operators of the instances that will result in successful claims. This command is the `tanzu service claimable list` command.

```
tanzu services claimable list --class cloudsql-postgres

  NAME                     NAMESPACE          KIND    APIVERSION
  sql-instance-claimable   service-instances  Secret  v1
```

Due to the setup done as part of creating a claimable class for Cloud SQL instances, the `Secret`s created from the `SecretTemplate` now appears as “claimable” to the Application Operator. From here on it is simply a case of creating a resource claim for the instance and then binding the claim to an Application Workload.

Create a claim for the newly created secret by running:

Note

Create the claim in the same namespace as your workload. If your workload is in a different namespace to the one currently targeted, add the `--namespace` flag to the above command.

```
tanzu service resource-claim create cloudsql-postgres-claim \
```

```
  --resource-name sql-instance-claimable \
  --resource-namespace service-instances \
  --resource-kind Secret \
  --resource-api-version v1
```

Obtain the claim reference of the claim by running:

```
tanzu service resource-claim list -o wide
```

Expect to see the following output:

```
NAME                      READY  REASON  CLAIM REF
cloudsql-postgres-claim  True   Ready   services.apps.tanzu.vmware.com/v1alpha1:Resour
ceClaim:cloudsql-postgres-claim
```

Create an Application Workload that consumes the claimed Cloud SQL Postgresql Database by running:

Example:

```
tanzu apps workload create my-workload \
  --git-repo https://github.com/sample-accelerators/spring-petclinic \
  --git-branch main \
  --git-tag tap-1.2 \
  --type web \
  --label app.kubernetes.io/part-of=spring-petclinic \
  --annotation autoscaling.knative.dev/minScale=1 \
  --env SPRING_PROFILES_ACTIVE=postgres \
  --service-ref db=services.apps.tanzu.vmware.com/v1alpha1:ResourceClaim:cloudsql-post
gres-claim
```

`--service-ref` is set to the claim reference obtained previously.

Congratulations - your Application Workload will now start up and will connect automatically to the Cloud SQL Service Instance. This can be verified by visiting the app in the browser and, for example, creating a new "Owner" through the GUI.

Prerequisites

Note

Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

The following prerequisites must be met in order to follow along with Consuming Cloud SQL on Tanzu Application Platform (TAP) with Config Connector.

The `gcloud` CLI

You need to have the `gcloud` CLI installed and authenticated.

A Kubernetes cluster

- with the Config Connector installed & configured
- with a stable Egress IP/CIDR range to allow access to the Cloud SQL instance (see further down at A Cloud NAT service)

In this example we went standard GKE cluster with the Config Connector pre-installed.

It is recommended to install the latest stable version of the Operator (1.71.0 is known to work with this specific use case).

```
GCP_PROJECT='<GCP project ID>'
LABELS='<label1=value1,label2=value2,...>'
CLUSTER_NAME='<GKE cluster name>'

# The Google Cloud Service Account to be used by the Config Connector
SA_NAME="${CLUSTER_NAME}-sa"

# The cluster's node count
# We suggest to start at 6 nodes to host all the TAP systems and to ensure
# the (automatically provisioned and managed) control plane is also scaled
# accordingly.
NODE_COUNT=6

# The namespace you want to deploy the Config Connector / service instance
# objects into
SI_NAMESPACE="service-instances"

# In this example we deploy a zonal cluster, thus you need to provide the
# zone you want your cluster to land in
ZONE='europe-west6-b'

# For Cloud NAT we need to provide the region we want to deploy the router
# to, this needs to be the region the zonal cluster resides in
REGION='europe-west6'

# Will be used for the name of the Cloud NAT router and the NAT config we
# deploy on it
NAT_NAME="${REGION}-nat"

gcloud container --project "${GCP_PROJECT}" \
    clusters create "${CLUSTER_NAME}" \
    --zone "${ZONE}" \
    --release-channel "regular" \
    --machine-type "e2-standard-4" \
    --disk-type "pd-standard" \
    --disk-size "70" \
    --metadata disable-legacy-endpoints=true \
    --num-nodes "${NODE_COUNT}" \
    --node-labels "${LABELS}" \
    --logging=SYSTEM \
    --monitoring=SYSTEM \
    --enable-ip-alias \
    --enable-network-policy \
    --addons ConfigConnector,HorizontalPodAutoscaling,HttpLoadBalancing,GcePersistentD
iskCsiDriver \
    --workload-pool="${GCP_PROJECT}.svc.id.goog" \
    --labels "${LABELS}"
```

```
gcloud iam service-accounts create \
    "${SA_NAME}" \
    --description "${LABELS}"

gcloud projects add-iam-policy-binding "${GCP_PROJECT}" \
    --member="serviceAccount:${SA_NAME}@${GCP_PROJECT}.iam.gserviceaccount.com" \
    --role="roles/editor"

gcloud iam service-accounts add-iam-policy-binding \
    "${SA_NAME}@${GCP_PROJECT}.iam.gserviceaccount.com" \
    --member="serviceAccount:${GCP_PROJECT}.svc.id.goog[cnrm-system/cnrm-controller-ma
nager]" \
    --role="roles/iam.workloadIdentityUser"
```

Configure a stable egress IP

By default egress traffic from pods will get their source IP translated to the node's public IP (SNAT) on the way out. Thus, when we need to configure allowed ingress networks for a Cloud SQL instance, we'd need to add each node of the cluster. Everytime the cluster scales or nodes get repaved, their public IP would change and we would need to make sure to keep the list of authorized networks up to date.

To make this easier we will: - turn off SNAT on the nodes, so egress traffic is not translated to the node's public IP - deploy a Cloud NAT service, which then handles the source IP translation and gives us a stable egress IP

Configure the `ip-masq-agent`

Each cluster comes with a `DaemonSet` `ip-masq-agent` in the `kube-system` namespace. By deploying a configuration for this service and restarting the `DaemonSet`, we can turn off SNAT for egress traffic.

```
cat <<'EOF' | kubectl -n kube-system create cm ip-masq-agent --from-file=config=/dev/s
tdin
nonMasqueradeCIDRs:
- 0.0.0.0/0
EOF

kubectl -n kube-system rollout restart daemonset ip-masq-agent
```

With this config none of the outbound traffic is translated to the node's public IP.

Note: You can also set specfic destination network CIDRs in `nonMasqueradeCIDRs` for which the SNAT on the nodes should be turned off. In that case, any traffic's source IP will still be translated to the node's public IP, except if the destination is explicitly configured in that list.

Set up a Cloud NAT service

After we've turned off SNAT on the nodes, we will employ a Cloud NAT service.

Conceptually this does the same thing as the SNAT on the nodes. However, the difference is, that we don't translate to a node's public IP address, but rather to a reserved IP address that is explicitly used by the Cloud NAT router. Therefore this IP is stable as long as this Cloud NAT router exists and all traffic originating from any pod, regardless which node it resides on, will get its source IP translated to that stable IP.

```
gcloud compute routers create "${NAT_NAME}-router" --region "${REGION}" --network defa
ult
gcloud compute routers nats create "${NAT_NAME}-config" \
    --router-region "${REGION}" \
    --router "${NAT_NAME}-router" \
    --auto-allocate-nat-external-ips \
    --nat-all-subnet-ip-ranges
```

A Tanzu Application Platform installation on the cluster (v1.2.0+).

Tanzu Application Platform (v1.2.0 or newer) and Cluster Essentials (v1.2.0 or newer) have to be installed on the kubernetes cluster.

Note: To check if you have an appropriate version, please run the following:

```
kubectl api-resources | grep secrettemplate
```

This command should return the `SecretTemplate` API. If it does not, ensure Cluster Essentials for VMware Tanzu (v1.2.0 or newer) is installed.

Configure the Config Connector

```
cat <<EOF | kubectl apply -f -
apiVersion: core.cnrm.cloud.google.com/v1beta1
kind: ConfigConnector
metadata:
  name: configconnector.core.cnrm.cloud.google.com
spec:
  mode: cluster
  googleServiceAccount: "${SA_NAME}@${GCP_PROJECT}.iam.gserviceaccount.com"
EOF

kubectl create namespace "${SI_NAMESPACE}"

kubectl annotate namespace "${SI_NAMESPACE}" "cnrm.cloud.google.com/project-id=${GCP_P
ROJECT}"

kubectl wait -n cnrm-system --for=condition=Ready pod --all

gcloud services enable serviceusage.googleapis.com
```

Get the NAT IP(s) for egress from the cluster

```
gcloud compute routers get-status "${NAT_NAME}-router" --region "${REGION}" --format=j
son \
  | jq -r '.result.natStatus[].autoAllocatedNatIps[]'
```

This IP(s) will later be used for allowing access to the CloudSQL instance from the cluster.

Creating Google CloudSQL Instances manually using kubectl

(experimental)

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.
>
> : This document is for users who are looking to understand the underlying APIs involved in making a bindable service instance using `SQLInstance`, `SQLDatabase`, `SQLUser` and `SecretTemplate` resources. For a simpler user experience, the alternative Creating an CloudSQL service instance through a Carvel Package topic is recommended.

Prerequisite

Meet the prerequisites and keep the following information to hand:

- `NAT-IP` - the cluster's egress NAT IP

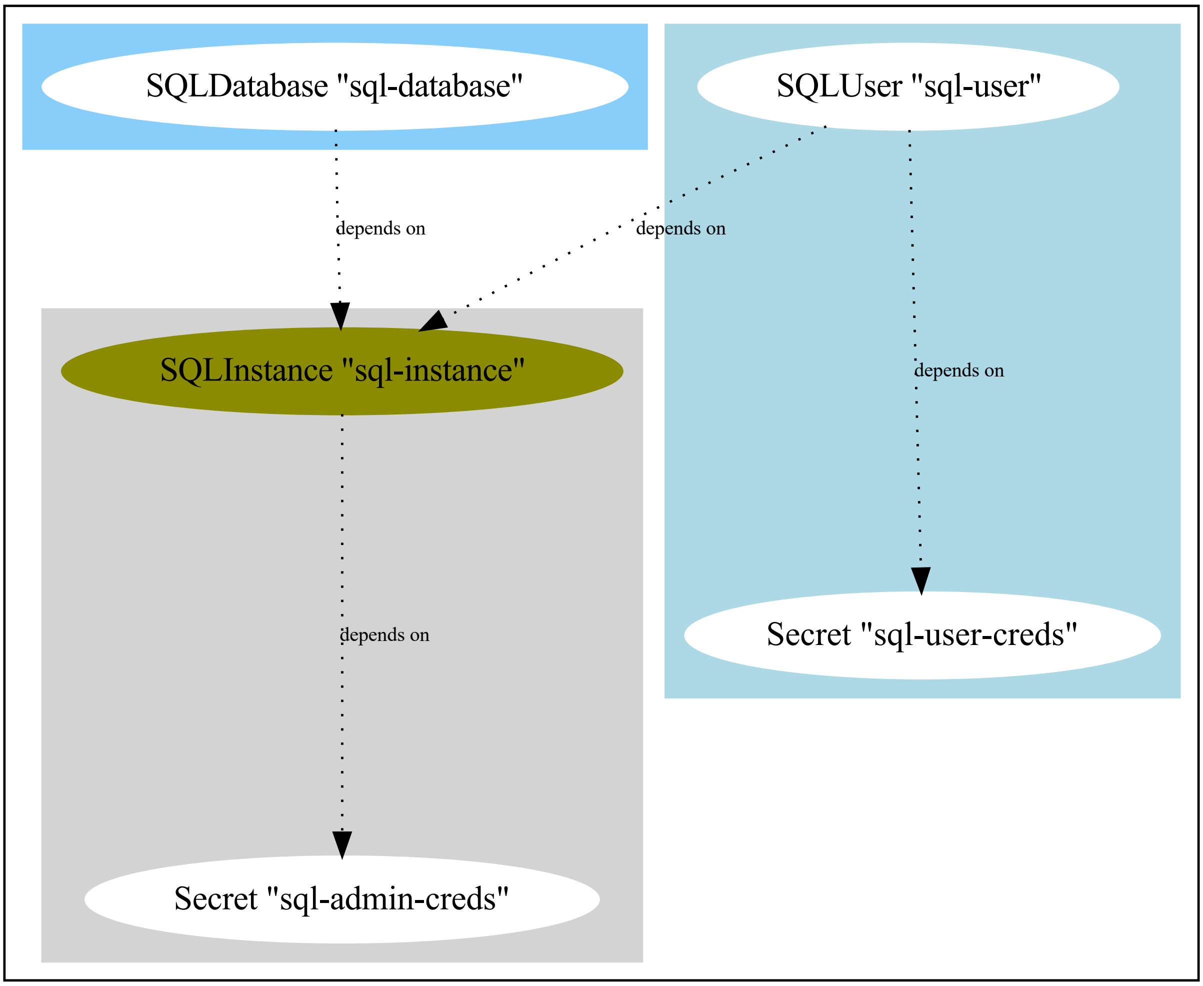
Create a CloudSQL service instance by using kubectl

At a minimum, a useable database instance consists of a `SQLInstance`, a `SQLDatabase`, and a `SQLUser`.

Realistically, in addition to that we will also want another set of `Secrets`:

- one `Secret` per `SQLInstance` to hold the password for the instance's admin role
- one `Secret` per `SQLUser` to hold that user's password

In the simplest case, with one `SQLInstance`, one `SQLDatabase`, and one `SQLUser`, we need to manage the following set of interrelated resources:



Create the `Secrets` for the Database admin & user

First we need to ensure that the `Secrets` which hold the admin's and user's password exist, so we can reference them in the `SQLInstance` and `SQLUser` objects.

Those secrets can be created by any means. In this guide will leverage the `Password` API from Carvel's secretgen controller, which will create the `Secrets` for us. However, any other mechanism to manage those secrets works too.

```
kind: List
apiVersion: v1
items:
- kind: Password
  apiVersion: secretgen.k14s.io/v1alpha1
  metadata:
    name: sql-admin-creds
    namespace: service-instances
  spec: &passwordSpec
    length: 64
    secretTemplate:
      type: Opaque
      stringData:
        password: $(value)
- kind: Password
  apiVersion: secretgen.k14s.io/v1alpha1
```

```
  metadata:
    name: sql-user-creds
    namespace: service-instances
  spec: *passwordSpec
```

Applying this will create two `Passwords` which in turn will have two `Secrets` created:

```
kubectl -n service-instances get passwords,secrets sql-user-creds sql-admin-creds
```

```
NAME                                             DESCRIPTION          AGE
password.secretgen.k14s.io/sql-user-creds    Reconcile succeeded   4m41s
password.secretgen.k14s.io/sql-admin-creds   Reconcile succeeded   4m41s

NAME                        TYPE      DATA   AGE
secret/sql-user-creds     Opaque    1       4m41s
secret/sql-admin-creds    Opaque    1       4m41s
```

Create a usable postgres database

Now we can reference those two secrets and use the Config Connector APIs to create our database objects:

> **Note**
>
> : You need to allow access from the Kubernetes cluster's NAT IP. You can get the NAT IP via the command described in the prerequisites. This NAT IP then needs to be used in the `SQLInstance`'s `spec.settings.ipConfiguration.authorizedNetworks`.

```
apiVersion: sql.cnrm.cloud.google.com/v1beta1
kind: SQLInstance
metadata:
  name: sql-instance
  namespace: service-instances
spec:
  databaseVersion: POSTGRES_14
  #! If you have deployed your cluster into a different region, you might want
  #! to change this and deploy the SQLInstance into the same region as the
  #! cluster, to avoid traffic going across regions.
  region: europe-west6
  rootPassword:
    valueFrom:
      secretKeyRef:
        key: password
        name: sql-admin-creds
  settings:
    tier: db-g1-small
    ipConfiguration:
      authorizedNetworks:
      - name: cluster-NAT-IP
        #! Update this value with your NAT IP address in CIDR notation (e.g. 8.8.8.8/3
2). See above.
        value: <NAT-IP>
      ipv4Enabled: true
---
```

```
apiVersion: sql.cnrm.cloud.google.com/v1beta1
kind: SQLDatabase
metadata:
  name: sql-database
  namespace: service-instances
spec:
  charset: UTF8
  collation: en_US.UTF8
  instanceRef:
    name: sql-instance
---
apiVersion: sql.cnrm.cloud.google.com/v1beta1
kind: SQLUser
metadata:
  name: sql-user
  namespace: service-instances
spec:
  instanceRef:
    name: sql-instance
  password:
    valueFrom:
      secretKeyRef:
        key: password
        name: sql-user-creds
```

Once those objects are committed to the Kubernetes API, the Config Connector will cause the creation of those resources on GCP. This will take a short amount of time.

The three resources report their status and potential problems/errors back. If all goes well we should see all of those resources as “Ready” & “UpToDate” after a couple of minutes.

```
# kubectl -n service-instances get sqlinstance,sqldatabase,sqluser
NAME                                                  AGE     READY   STATUS      STATUS
 AGE
sqlinstance.sql.cnrm.cloud.google.com/sql-instance    3d20h   True    UpToDate    3d20h

NAME                                                  AGE     READY   STATUS      STATUS
 AGE
sqldatabase.sql.cnrm.cloud.google.com/sql-database    3d20h   True    UpToDate    3d20h

NAME                                          AGE     READY   STATUS      STATUS  AGE
sqluser.sql.cnrm.cloud.google.com/sql-user    3d20h   True    UpToDate    3d20h
```

You can also see this Cloud SQL instance in the Google Cloud Console.

> **Note**
>
> : Cloud SQL does not allow you to reuse the name of a deleted instance for a week. If you try to create a new `SQLInstance` with a name you have already used previously, you will see an error like
>
> > **Note**
> >
> > […] When you delete an instance, you can’t reuse the name of the deleted instance until one week from the deletion date. […]

You can use a different name for the `SQLInstance`; make sure to use replace that name in all examples going forward.

Create a Binding Specification compatible Secret for the database

As pointed out, none of the created objects are compatible with the Service Binding Specification. To help with that, we can create a secret which holds the data we need to know to connect to and use the Cloud SQL instance and which allows the platform to discover the fact that this instance can be “claimed” and “bound” to application workloads.

For this to be an automated process, we can use the `SecretTemplate` API of the secretgen controller. The secretgen controller needs to be able to read the resources created, thus we also need to deploy some RBAC rules to allow for that:

```
apiVersion: secretgen.carvel.dev/v1alpha1
kind: SecretTemplate
metadata:
  name: sql-instance-claimable
  namespace: service-instances
spec:
  inputResources:
  - name: sqlInstance
    ref:
      apiVersion: sql.cnrm.cloud.google.com/v1beta1
      kind: SQLInstance
      name: sql-instance
  - name: sqlDatabase
    ref:
      apiVersion: sql.cnrm.cloud.google.com/v1beta1
      kind: SQLDatabase
      name: sql-database
  - name: sqlUser
    ref:
      apiVersion: sql.cnrm.cloud.google.com/v1beta1
      kind: SQLUser
      name: sql-user
  - name: sqlUserSecret
    ref:
      apiVersion: v1
      kind: Secret
      name: $(.sqlUser.spec.password.valueFrom.secretKeyRef.name)
  serviceAccountName: sql-objects-reader
  template:
    data:
      password: $(.sqlUserSecret.data.password)
    metadata:
      labels:
        app.kubernetes.io/component: cloudsql-postgres
        app.kubernetes.io/instance: "$(.sqlInstance.metadata.name)"
        services.apps.tanzu.vmware.com/class: cloudsql-postgres
    stringData:
      database: $(.sqlDatabase.metadata.name)
      host: $(.sqlInstance.status.publicIpAddress)
      port: "5432"
      type: postgresql
```

```
      username: $(.sqlUser.metadata.name)
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: sql-objects-reader
  namespace: service-instances
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: sql-objects-reader
  namespace: service-instances
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: sql-objects-reader
subjects:
- kind: ServiceAccount
  name: sql-objects-reader
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: sql-objects-reader
  namespace: service-instances
rules:
- apiGroups:     [ "" ]
  resources:     [ "secrets" ]
  verbs:         &objReaderVerbs [ "get", "list", "watch" ]
  resourceNames: [ "sql-user-creds", "sql-admin-creds" ]
- apiGroups:     [ "sql.cnrm.cloud.google.com" ]
  resources:     [ "sqlinstances", "sqldatabases", "sqlusers" ]
  verbs:         *objReaderVerbs
  resourceNames: [ "sql-instance", "sql-database", "sql-user" ]
```

Verify

Find the name of the secret produced by reading the status of `SecretTemplate`. To do so, run:

```
kubectl get secrettemplate -n service-instances sql-instance-claimable -o jsonpath="{.
status.secret.name}"
```

Delete a CloudSQL service instance

Delete an CloudSQL service instance and all additional and related objects by running:

```
kubectl -n service-instances delete \
  sqlinstance/sql-instance \
  sqldatabase/sql-database \
  sqluser/sql-user \
  secrettemplate/sql-instance-claimable \
  password/sql-admin-creds \
  password/sql-user-creds \
  serviceaccount/sql-objects-reader \
  rolebinding/sql-objects-reader \
```

```
roles/sql-objects-reader
```

Summary and Next Steps

You have learned how to use Carvel's `SecretTemplate` API to construct a secret that is compatible with the binding specification in order to create an Google CloudSQL service instance.

Now that you have this available in the cluster, you can learn how to make use of it by continuing where you left off in Consuming Google Cloud SQL on Tanzu Application Platform (TAP) with Config Connector.

Creating Google CloudSQL instances by using a Carvel package (experimental)

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes how to create, update, and delete CloudSQL service instances using a Carvel package. For a more detailed and low-level alternative procedure, see Creating Service Instances that are compatible with Tanzu Application Platform.

Prerequisite

Meet the prerequisites and keep the following information to hand:

- `NAT-IP` - the cluster's egress NAT IP

The Package Repository and service instance Package Bundles for this guide can be found in the Reference Service Packages GitHub repository.

Create an CloudSQL service instance using a Carvel package

Follow the steps in the following procedures.

Add a reference package repository to the cluster

To add a reference package repository to the cluster:

1. Use the Tanzu CLI to add the new Service Reference packages repository:

   ```
   tanzu package repository add tap-reference-service-packages \
     --url ghcr.io/vmware-tanzu/tanzu-application-platform-reference-packages/tap-service-reference-package-repo:0.0.2 \
     -n tanzu-package-repo-global
   ```

2. Create a `ServiceAccount` that is used to provision `PackageInstall` resources by using the following example. The namespace of this `ServiceAccount` must match the namespace of the `tanzu package install` command in the next step.

```
kubectl apply -f - <<'EOF'
apiVersion: v1
kind: ServiceAccount
metadata:
  name: cloudsql-install
  namespace: service-instances
---
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: cloudsql-install
  namespace: service-instances
rules:
- apiGroups: ["sql.cnrm.cloud.google.com"]
  resources: ["sqlinstances","sqldatabases","sqlusers"]
  verbs:     ["*"]
- apiGroups: ["secretgen.carvel.dev", "secretgen.k14s.io"]
  resources: ["secrettemplates","passwords"]
  verbs:     ["*"]
- apiGroups: [""]
  resources: ["serviceaccounts","configmaps"]
  verbs:     ["*"]
- apiGroups: ["rbac.authorization.k8s.io"]
  resources: ["roles","rolebindings"]
  verbs:     ["*"]
---
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: cloudsql-install
  namespace: service-instances
subjects:
- kind: ServiceAccount
  name: cloudsql-install
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: cloudsql-install
EOF
```

Create a CloudSQL service instance through the Tanzu CLI

1. Create a file holding the configuration of the CloudSQL service instance:

```
cat <<'EOF' > demo-pg-instance-values.yml
---
name: demo-pg-instance
namespace: service-instances
allowedNetworks:
- name: service-instances-cluster-snat
  #! replace that with the cluster's egress IP, see NAT-IP in Prerequisite
  value: 34.65.178.24/32
EOF
```

Note

: To understand which settings are available for this package you can run:

```
tanzu package available get \
  --values-schema \
  psql.google.references.services.apps.tanzu.vmware.com/0.0.1-alph
a
```

This shows a list of all configuration options you can use in the `demo-pg-instance-values.yml` file.

: By default the package will create a claimable `Secret` which is labeled with `services.apps.tanzu.vmware.com/class: cloudsql-postgres`. While you can overwrite that by setting the `serviceInstanceLabels` setting above, you don't have to do that and it will still be aligned with the `ClusterInstanceClass` we will set up later.

2. Use the Tanzu CLI to install an instance of the reference service instance Package.

```
tanzu package install demo-pg-instance \
   --package-name psql.google.references.services.apps.tanzu.vmware.com \
   --version 0.0.1-alpha \
   --namespace service-instances \
   --service-account-name cloudsql-install \
   --values-file demo-pg-instance-values.yml \
   --wait
```

You can install the `psql.google.references.services.apps.tanzu.vmware.com` package multiple times to produce multiple CloudSQL Service instances. For that you need to prepare a separate `<INSTANCE-NAME>-values.yml` and then install the package with a different name and the above mentioned separate data values file for each CloudSQL service instance.

Verify

1. Verify the creation status for the CloudSQL instance by inspecting the conditions in the Kubernetes API. To do so, run:

```
kubectl get sqlinstance demo-pg-instance -n service-instances -o yaml
```

2. After some time has passed, sometimes up to 20 minutes, you are able to find the binding-compliant secret produced by `PackageInstall`. To do so, run:

```
kubectl get secrettemplate demo-pg-instance -n service-instances -o jsonpath="{
.status.secret.name}"
```

Delete a CloudSQL service instance

To delete the CloudSQL service instance run:

```
tanzu package installed delete demo-pg-instance -n service-instances
```

Summary

You have learned how to use Carvel's `Package` and `PackageInstall` APIs to create a CloudSQL service instance. If you want to learn more about the pieces that comprise this service instance package, see Creating Google CloudSQL Instances manually using kubectl.

Now that you have this available in the cluster, you can learn how to make use of it by continuing where you left off in [Consuming Google Cloud SQL on Tanzu Application Platform (TAP) with Config Connector][create-class].

Consuming GCP CloudSQL on Tanzu Application Platform with Crossplane

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Introduction

This topic demonstrates how to use Services Toolkit to allow Tanzu Application Platform workloads to consume GCP CloudSQL PostgreSQL databases. This particular guide makes use of Crossplane to manage CloudSQL instances in GCP. As such, it can be thought of as an alternative approach to Consuming Google Cloud SQL on Tanzu Application Platform (TAP) with Config Connector to achieve the same outcomes.

Note This usecase is not currently compatible with TAP air-gapped installations.

Prerequisites

Meet these prerequisites:

- Create a Kubernetes cluster that supports running both Tanzu Application Platform and Crossplane
- Install Tanzu Application Platform (v1.2+) on the Kubernetes cluster
- Install gcloud CLI
- Ensure the Cloud SQL Admin API is enabled in your GCP Project

Install Crossplane

> **Note**
>
> : For the latest steps for installing Crossplane, see these instructions. For the instructions in this topic, it is important to enable support for external secret stores in Crossplane. This is currently an Alpha feature. As such, you will have to explicitly set command line flag `--enable-external-secret-stores` when starting the Crossplane controller.

Run the following commands to install Crossplane to your existing Kubernetes cluster:

```
kubectl create namespace crossplane-system

helm repo add crossplane-stable https://charts.crossplane.io/stable
helm repo update

helm install crossplane --namespace crossplane-system crossplane-stable/crossplane \
  --set 'args={--enable-external-secret-stores}'
```

For this topic, you do not need to install the Crossplane CLI or any additional configuration package.

Install GCP Provider for Crossplane

To install the GCP Provider for Crossplane, run:

```
kubectl apply -f -<<EOF
---
apiVersion: pkg.crossplane.io/v1
kind: Provider
metadata:
  name: crossplane-provider-gcp
spec:
  package: crossplane/provider-gcp:v0.21.0
EOF
```

After you have installed the provider, you see a new `cloudsqlinstances.database.gcp.crossplane.io` API resource available in your Kubernetes cluster. See the health of the installed provider by running:

```
kubectl get provider.pkg.crossplane.io crossplane-provider-gcp
```

Configure GCP Provider

This section creates a new GCP Service Account and gives it permissions to manage CloudSQL databases which are necessary to use Crossplane to manage CloudSQL instances.

1. Create a new GCP ServiceAccount, give it `Cloud SQL Admin` and create a key file:

```
PROJECT_ID=<GCP Project ID>
SA_NAME=crossplane-cloudsql

gcloud iam service-accounts create "${SA_NAME}" --project "${PROJECT_ID}"
gcloud projects add-iam-policy-binding "${PROJECT_ID}" \
  --role="roles/cloudsql.admin" \
  --member "serviceAccount:${SA_NAME}@${PROJECT_ID}.iam.gserviceaccount.com"
gcloud iam service-accounts keys create creds.json --project "${PROJECT_ID}" --
iam-account "${SA_NAME}@${PROJECT_ID}.iam.gserviceaccount.com"
```

2. Create a new secret from the key file by running:

```
kubectl create secret generic gcp-creds -n crossplane-system --from-file=creds=
./creds.json
```

3. Delete the key file by running:

```
rm -f creds.json
```

4. Configure the GCP provider to use the newly created secret by running:

```
kubectl apply -f -<<EOF
apiVersion: gcp.crossplane.io/v1beta1
kind: ProviderConfig
metadata:
  name: default
spec:
  projectID: ${PROJECT_ID}
  credentials:
    source: Secret
    secretRef:
      namespace: crossplane-system
      name: gcp-creds
      key: creds
EOF
```

Define Composite Resource Types

Now that the GCP provider for Crossplane has been installed and configured, create a new `CompositeResourceDefinition` (XRD) and corresponding `Composition` representing individual instances of CloudSQL Postgresql. For more information about these concepts see the Crossplane Composition documentation.

Note: Instead of creating your own custom XRD and Composition as shown below, you can also install an existing Crossplane configuration package for GCP that includes pre-configured XRDs and compositions for CloudSQL. The primary reason for creating a new XRD and composition from scratch is to make sure the connection secrets for newly provisioned CloudSQL Postgresql instances support the Service Binding Specification for Kubernetes and automatic Spring Boot configuration using Spring Cloud Bindings.

1. Create a new XRD by running:

```
kubectl apply -f -<<EOF
---
apiVersion: apiextensions.crossplane.io/v1
kind: CompositeResourceDefinition
metadata:
  name: xpostgresqlinstances.bindable.database.example.org
spec:
  claimNames:
    kind: PostgreSQLInstance
    plural: postgresqlinstances
  connectionSecretKeys:
  - type
  - provider
  - host
  - port
  - database
  - username
```

```
  - password
  group: bindable.database.example.org
  names:
    kind: XPostgreSQLInstance
    plural: xpostgresqlinstances
  versions:
  - name: v1alpha1
    referenceable: true
    schema:
      openAPIV3Schema:
        properties:
          spec:
            properties:
              parameters:
                properties:
                  storageGB:
                    type: integer
                required:
                - storageGB
                type: object
            required:
            - parameters
            type: object
        type: object
    served: true
EOF
```

After the newly created XRD has been successfully reconciled, there are two new API resources available in your Kubernetes cluster, `xpostgresqlinstances.bindable.database.example.org` and `postgresqlinstances.bindable.database.example.org`. The XRD created is agnostic to the underlying cloud managed service, so could also be fulfilled by a Composition that makes use of AWS RDS Postgresql or Azure Database for PostgreSQL.

2. Create a corresponding composition (not in a production environment) by running:

```
kubectl apply -f -<<EOF
---
apiVersion: apiextensions.crossplane.io/v1
kind: Composition
metadata:
  labels:
    provider: gcp
  name: xpostgresqlinstances.bindable.gcp.database.example.org
spec:
  compositeTypeRef:
    apiVersion: bindable.database.example.org/v1alpha1
    kind: XPostgreSQLInstance
  publishConnectionDetailsWithStoreConfigRef:
    name: default
  resources:
  - base:
      apiVersion: database.gcp.crossplane.io/v1beta1
      kind: CloudSQLInstance
      spec:
        forProvider:
          databaseVersion: POSTGRES_14
          region: us-central1
```

```
          settings:
            dataDiskType: PD_SSD
            ipConfiguration:
              authorizedNetworks:
              - value: 0.0.0.0/0 # not recommended for production deployments!
              ipv4Enabled: true
            tier: db-custom-1-3840
        writeConnectionSecretToRef:
          namespace: crossplane-system
    connectionDetails:
    - name: type
      value: postgresql
    - name: provider
      value: gcp
    - name: database
      value: postgres
    - fromConnectionSecretKey: username
    - fromConnectionSecretKey: password
    - name: host
      fromConnectionSecretKey: endpoint
    - name: port
      type: FromValue
      value: "5432"
    name: cloudsqlinstance
    patches:
    - fromFieldPath: metadata.uid
      toFieldPath: spec.writeConnectionSecretToRef.name
      transforms:
      - string:
          fmt: '%s-postgresql'
          type: Format
        type: string
      type: FromCompositeFieldPath
    - fromFieldPath: spec.parameters.storageGB
      toFieldPath: spec.forProvider.settings.dataDiskSizeGb
      type: FromCompositeFieldPath
EOF
```

The composition defined above makes sure that all CloudSQL Postgresql instances are placed in the `us-central1` region. This composition fulfils the XRD previously created by creating GCP CloudSQL databases.

Caution: The authorized network CIDR `0.0.0.0/0` provided above, will allow access to the Cloud SQL from any IP and is not recommended in a production environment.

Create an Instance Class

In order to make instances of a service easily discoverable and claimable by application operators, the role of the service operator creates a `ClusterInstanceClass`. In this particular example, the class states that claimable instances of CloudSQL Postgresql are represented by secret objects of type `connection.crossplane.io/v1alpha1` with label `services.apps.tanzu.vmware.com/class` set to `cloudsql-postgres`:

```
kubectl apply -f -<<EOF
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
```

```
kind: ClusterInstanceClass
metadata:
  name: cloudsql-postgres
spec:
  description:
    short: GCP CloudSQL Postgresql database instances
  pool:
    kind: Secret
    labelSelector:
      matchLabels:
        services.apps.tanzu.vmware.com/class: cloudsql-postgres
    fieldSelector: type=connection.crossplane.io/v1alpha1
EOF
```

In addition, you need to grant sufficient RBAC permissions to Services Toolkit to be able to read the secrets specified by the class.

```
kubectl apply -f -<<EOF
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: stk-secret-reader
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
  - list
  - watch
EOF
```

Provision GCP CloudSQL Postgresql Instance

Playing the role of the Service Operator, you now provision an instance of GCP CloudSQL Postgresql using the `postgresqlinstances.bindable.database.example.org` API managed by the XRD you previously created. Note that `.spec.publishConnectionDetailsTo` provides Crossplane with the name and a label for the secret that is being used to store the connection details for the newly created database. You can see that the label specified here matches the label selector defined on the `ClusterInstanceClass` you created in the previous step.

Run the following command:

```
kubectl apply -f -<<EOF
---
apiVersion: bindable.database.example.org/v1alpha1
kind: PostgreSQLInstance
metadata:
  name: cloudsql-postgres-db
  namespace: default
spec:
  parameters:
```

```
    storageGB: 20
  compositionSelector:
    matchLabels:
      provider: gcp
  publishConnectionDetailsTo:
    name: cloudsql-postgres-db
    metadata:
      labels:
        services.apps.tanzu.vmware.com/class: cloudsql-postgres
EOF
```

> **Caution**
>
> If you are planning to create this resource using Namespace Provisioner, then you must take steps to prevent the Namespace Provisioner from overwriting changes that get written to the `PostgreSQLInstance` resource by Crossplane as part of its reconciliation loop. One way of achieving that is to append the following kapp Config rebaseRules to the same file as the `PostgreSQLInstance` in your gitops repository.

```
---
apiVersion: kapp.k14s.io/v1alpha1
kind: Config
rebaseRules:
- path: [spec, resourceRef]
  type: copy
  sources: [existing]
  resourceMatchers:
   - apiVersionKindMatcher: {apiVersion: bindable.database.example.org/v1alpha1, kind:
 PostgreSQLInstance}
```

This additional configuration is not required if you create the PostgreSQLInstance manually.

Running this command will cause the creation of a CloudSQL database instance in your GCP account. You can use the gcloud CLI to verify this:

```
gcloud sql instances list
```

After the instance has been successfully created in GCP, the status of the newly created `PostgreSQLInstance` resource should show `READY=True`. This might take a few minutes. You can wait for this by running:

```
kubectl wait --for=condition=Ready=true postgresqlinstances.bindable.database.example.
org cloudsql-postgres-db --timeout=10m
```

As soon as the CloudSQL Postgresql instance is ready, it is claimable by the role of the application operator as shown in the next section.

Claim the CloudSQL Postgresql instance and connect to it from the Tanzu Application Platform Workload

Thanks to the previously created `ClusterInstanceClass`, secrets representing CloudSQL Postgresql instances can now be discovered and claimed by application operators through the Tanzu CLI as shown below.

1. Show available classes of service instances by running:

```
tanzu service classes list

  NAME                    DESCRIPTION
  cloudsql-postgres       GCP CloudSQL Postgresql database instances
```

2. Show claimable instances belonging to the CloudSQL Postgresql class by running:

```
tanzu services claimable list --class cloudsql-postgres

  NAME                        NAMESPACE  API KIND   API GROUP/VERSION
  cloudsql-postgres-db        default    Secret     v1
```

3. Create a claim for the discovered instance by running:

> **Note**
>
> Create the claim in the same namespace as your workload. If your workload is in a different namespace to the one currently targeted, add the `--namespace` flag to the above command.

```
tanzu service resource-claim create cloudsql-claim \
  --resource-name cloudsql-postgres-db \
  --resource-kind Secret \
  --resource-api-version v1
```

4. Obtain the claim reference by running:

```
tanzu service resource-claim list -o wide
```

Expect to see the following output:

```
NAME                         READY  REASON  CLAIM REF
cloudsql-claim               True           services.apps.tanzu.vmware.com/v1alpha1
:ResourceClaim:cloudsql-claim
```

5. Create an application workload that consumes the claimed CloudSQL Postgresql database by running:

Example:

```
tanzu apps workload create my-workload \
  --git-repo https://github.com/sample-accelerators/spring-petclinic \
  --git-branch main \
  --git-tag tap-1.2 \
  --type web \
  --label app.kubernetes.io/part-of=spring-petclinic \
  --annotation autoscaling.knative.dev/minScale=1 \
  --env SPRING_PROFILES_ACTIVE=postgres \
  --service-ref db=services.apps.tanzu.vmware.com/v1alpha1:ResourceClaim:clouds
```

```
ql-claim
```

Note that `--service-ref` is being set to the claim reference obtained previously.

Component API Documentation

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This section of the documentation provides detailed, technical documentation for each of the APIs provided by Services Toolkit. The documentation is split according to component, and can be accessed via the table of contents.

Resource Claims

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Install

See the documentation on installing the latest release of the Services Toolkit to get started.

Resources

ResourceClaim

The main purpose of `ResourceClaim` is to identify the concrete Kubernetes object within the cluster that satisfies the requirements stated in the claim.

After the object is identified, the status condition `ResourceMatched` is set to `true`. If the reference object adheres to the provisioned service duck type the `.status.binding.name` is copied to the `ResourceClaim`'s `.status.binding.name` and the `ResourceClaimed` condition is set to `true`. The claim object itself is a provisioned service, so it can be used to define a `ServiceBinding`.

`ResourceClaims` are currently exclusive. A Service Resource can only have one successfully claimed `ResourceClaim` in the cluster.

To learn more about when to use `ResourceClaim` vs `ClassClaim`, see When to use `ClassClaim` vs `ResourceClaim`

```
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
```

```
kind: ResourceClaim
metadata:
  name: rmq-claim
  namespace: accounts
spec:
  ref:
    apiVersion: rabbitmq.com/v1alpha1
    kind: RabbitmqCluster
    name: my-rmq
    namespace: my-rmq-namespace # optional (if claiming across namespaces)
status:
  binding:
    name: my-rmq-secret # copied from RabbitmqCluster/my-rmq
  conditions:
    - lastTransitionTime: "2019-10-22T16:29:25Z"
      status: "True"
      type: Ready
    - lastTransitionTime: "2019-10-22T16:29:24Z"
      status: "True"
      type: ResourceClaimed
    - lastTransitionTime: "2019-10-22T16:29:23Z"
      status: "True"
      type: ResourceMatched
```

ResourceClaimPolicy

`ResourceClaimPolicy` enables `ResourceClaims` to work across namespaces.

The policy refers to two pieces of information:

- Service Resources, such as RabbitmqClusters, that this policy applies to
- The namespaces allowed to claim these resources

The matching Service Resources must reside in the same namespace as the `ResourceClaimPolicy` and their type must also be specified in `.spec.subject`.

Namespaces that are allowed to claim these service resources must have their namespace name in the `.spec.consumingNamespaces` array. A value of `*` allows claiming from all namespaces in this cluster.

```
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ResourceClaimPolicy
metadata:
  name: rmq-policy
  namespace: my-rmq-namespace
spec:
  consumingNamespaces:
  - accounts # or "*" for all namespaces
  subject:
    group: rabbitmq.com
    kind: RabbitmqCluster
    selector: # optional
      matchLabels:
        "key": "value"
      matchExpressions:
      - key: "key"
        operator: In
```

```
      values: ["value1", "value2"]
```

ClassClaim

The main purpose of `ClassClaim` is to express the need to access a provisioned service for a given `ClusterInstanceClass`.

After the target `ClusterInstanceClass` is identified, the status condition `ClassMatched` is set to `true`. If there is an unclaimed instance of that class that can be claimed from the `ClassClaim`'s namespace then the status condition `ResourceMatched` is set to `true`. If that instance adheres to the provisioned service duck type, the `.status.binding.name` is copied to the `ClassClaim`'s `.status.binding.name` and the `ResourceClaimed` condition are set to `true`. The claim object itself is a provisioned service, so it can be used to define a `ServiceBinding`.

`ClassClaim`s are currently exclusive with regards to the Service Resource they can claim. In order words, many `ClassClaim`s can claim from the same `ClusterInstanceClass` but can not result in claiming the same Service Resource. Also the spec field `classRef` is immutable as it can only be set a creation time of the `ClassClaim`.

To learn more about when to use `ResourceClaim` vs `ClassClaim`, see When to use `ClassClaim` vs `ResourceClaim`

```
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClassClaim
metadata:
  name: rmq-claim
  namespace: accounts
spec:
  classRef: # can only be set at creation time
    name: rmq-class
status:
  binding:
    name: my-rmq-secret # copied from a RabbitmqCluster of the class
  conditions:
    - lastTransitionTime: "2019-10-22T16:29:22Z"
      status: "True"
      type: ClassClaimed
    - lastTransitionTime: "2019-10-22T16:29:25Z"
      status: "True"
      type: Ready
    - lastTransitionTime: "2019-10-22T16:29:24Z"
      status: "True"
      type: ResourceClaimed
    - lastTransitionTime: "2019-10-22T16:29:23Z"
      status: "True"
      type: ResourceMatched
```

ClusterInstanceClass

`ClusterInstanceClass` represents a set of service instances. It holds metadata that describes what service instances belong in this class.

The `ClusterInstanceClass` provides a description of the types of service instances represented by this class (`.spec.description`) and also the traits that a resource needs to be part of the class

(`.spec.pool`). For example, its kind and the labels it has.

```
---
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterInstanceClass
metadata:
  name: test
spec:
  description:
    short: test
  pool:
    group: "" # optional field if the group is ""
    kind: Secret
    labelSelector: # optional
      matchLabels:
        service: "rds-postgres"
        claimable: "true"
```

InstanceQuery

`InstanceQuery` is a create-only API that, given a `ClusterInstanceClass`, returns the intersection of the set of service instances represented by that class and the claimable service instances for the namespace of the `InstanceQuery`.

The `InstanceQuery` takes an input of a `ClusterInstanceClass` through `.spec.class` and an optional limit on the number of instances returned through `.spec.limit`. This defaults to `50`.

```
---
apiVersion: claimable.services.apps.tanzu.vmware.com/v1alpha1
kind: InstanceQuery
metadata:
  name: test
spec:
  class: my-db-class
  limit: 30
status:
  instances:
  - apiVersion: v1
    kind: Secret
    name: my-secret-two
    namespace: default
  - apiVersion: v1
    kind: Secret
    name: my-secret-ns-one
    namespace: one
```

Permissions (RBAC)

The `ResourceClaim` controller MUST have read access to Resources specified in the `ResourceClaim` specification. As these resources are not known upfront, the appropriate RBAC must be setup on the Cluster. To accomplish this RBAC must be set up using Aggregated ClusterRoles with the `servicebinding.io/controller: "true"` label. For more information, see the Kubernetes documentation

An example of a ClusterRole that allows `RabbitmqCluster` resources to be read by the `ResourceClaim` controller:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: resource-claims-rmq-role
  labels:
    servicebinding.io/controller: "true"
rules:
- apiGroups:
  - rabbitmq.com
  resources:
  - rabbitmqclusters
  verbs:
  - get
  - list
  - watch
```

When to use ClassClaim vs ResourceClaim

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

With the introduction of `ClassClaim`, there are now two ways of requesting access to a Service Resource: `ClassClaim` and `ResourceClaim`. This section explains the similarities and differences between the two APIs and when usage of one is preferable over the other. It is advisable to work with `ClassClaim`s where possible as they are easier to create and are more portable across multiple clusters.

Similarities

- Both APIs express the need for access to a Service Resource.
- Both APIs adhere to the `ProvisionedService` duck type. In order words, they both have the field `.status.binding.name` in their API. This means that they both can be targeted via a `ServiceBinding` and therefore both can be fed into Cartographer's `Workload` API.
- Both APIs rely on a `ResourceClaimPolicy` in order to achieve cross-namespace claiming.
- Both APIs ensure mutual exclusivity of claims on Service Resources. That is to say that that a `ClassClaim` or a `ResourceClaim` will never result in claiming the same Service Resource as another `ClassClaim` or `ResourceClaim`.

`ResourceClaim`

A `ResourceClaim` targets a specific resource in the Kubernetes cluster. To target that resource, the `ResourceClaim` needs the name, namespace, kind, and API version of the resource.

The specificity of the `ResourceClaim` means it is most useful when:

- There's need to be a strong guarantee which Service Resource the application workload will be utilising. For example, if the application needs to connect to exact same database instance as it promotes through development, test, and production environments.
- This is a experimental or demo environment so creating the `ClusterInstanceClass` and `ClassClaim` would be superfluous effort.

If neither of the above are true, then it is recommended to look at the `ClassClaim` API instead.

`ClassClaim`

A `ClassClaim` targets a `ClusterInstanceClass` in the Kubernetes cluster. To target that class, the `ClassClaim` just needs its name. The `ClusterInstanceClass` can represent any set of service instances and therefore each time you create a new `ClassClaim`, you could claim any of the service instances represented by that `ClusterInstanceClass`. Once a `ClassClaim` has claimed a service instance, then it will never look for another. This is true even if the `ClassClaim`'s spec is updated or the `ClusterInstanceClass` is updated. Therefore the `ClassClaim` is performing a **point-in-time** lookup at its creation, utilising the `ClusterInstanceClass` for that lookup.

The loose coupling between the `ClassClaim` and the Service Resources means that `ClassClaim`s are great in situations where:

- Different Service Resources need to be injected into the application workload at different points in its promotion from development to production environments.
- The `ClassClaim` (perhaps along with a `Workload` referencing it) need to be promoted from one environment to the next without changing their specification.

Services plug-in for Tanzu CLI

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.
>
> **Caution:** The former `tanzu service types list` and `tanzu service instance list` commands are now deprecated. They have been hidden from CLI output text but are still functional if invoked. Support for these commands ends either after two minor releases (v0.6.0) or after one year (2023-07-12), whichever occurs later. Use the alternative commands `tanzu service class list` and `tanzu service claimable list` instead.

The Services plug-in improves the user experience of working with services on Tanzu Application Platform. After installation, the plug-in is invoked by running the `tanzu services` command.

The plug-in is currently distributed with Tanzu Application Platform. See Install or update the Tanzu CLI and plug-ins for information on how to acquire and install the plug-in.

Use cases

The Services plug-in for Tanzu CLI is currently of most use to the application developer and application operator roles. See Terminology and User Roles for more details. The following use cases are currently covered by the plug-in as documented below.

Discover service instance classes

Service instance classes can be discovered by running:

```
tanzu service classes list
```

For further information including help text and usage, run:

```
tanzu service classes list --help
```

Discover claimable service instances

Discover claimable service instance for a given class can be discovered by running:

```
tanzu service claimable list --class CLASS-NAME
```

Where `CLASS-NAME` is the name of a `ClusterInstanceClass` to discover claimable service instances from.

For further information including help text and usage, run:

```
tanzu service claimable list --help
```

Create ClassClaims

Given a `ClusterInstanceClass`, Application operators can claim service instances on their target cluster by running:

```
tanzu service class-claim create
CLAIM-NAME --class CLASS-NAME
```

Where:

- `CLAIM-NAME` is the desired name of the `ClassClaim` to be created.
- `CLASS-NAME` is the name of the `ClusterInstanceClass` to use to discover and claim a resource.

For further information including help text and usage, run:

```
tanzu service class-claim create --help
```

List and Get ClassClaims

Application developers can view existing class claims on their target cluster by running:

```
tanzu service class-claim list
```

In addition, application developers can use this command to output claim references by passing in `-o` `wide`, which can then be passed to the `--service-ref` flag of the `tanzu apps workload create` command in order to bind application workloads to service instances.

For further information including help text and usage, run:

```
tanzu service class-claim list --help
```

To further interrogate the `ClassClaim` for details, run:

```
tanzu service class-claim get CLASS-NAME
```

Where `CLAIM-NAME` is the name of the `ClassClaim` that currently is claiming the service instance.

Delete ClassClaims

Application operators can unclaim a service instance, which was claimed via a `ClassClaim`, on their target cluster by running:

```
tanzu service class-claim delete CLAIM-NAME
```

Where `CLAIM-NAME` is the name of the `ClassClaim` that currently is claiming the service instance.

For further information including help text and usage, run:

```
tanzu service class-claims delete --help
```

Create ResourceClaims

Application operators can claim a specific service instances on their target cluster by running:

```
tanzu service resource-claim create CLAIM-NAME \
  --resource-name SERVICE-INSTANCE-NAME \
  --resource-kind SERVICE-INSTANCE-KIND \
  --resource-api-version SERVICE-INSTANCE-API-VERSION
```

Where:

- `CLAIM-NAME` is the desired name of the Resource Claim to be created.
- `SERVICE-INSTANCE-NAME`, `SERVICE-INSTANCE-KIND` and `SERVICE-INSTANCE-API-VERSION` are the name, kind and apiVersion, respectively, of the service instance to be claimed.
- `--resource-namespace` is an optional flag that can be passed in with a namespace to claim a service instance in a different namespace.

For further information including help text and usage, run:

```
tanzu service resource-claim create --help
```

List and Get ResourceClaims

Application developers can view existing `ResourceClaims` on their target cluster by running:

```
tanzu service resource-claim list
```

In addition, application developers can use this command to output claim references by passing in `-o wide`, which can then be passed to the `--service-ref` flag of the `tanzu apps workload create` command in order to bind application workloads to service instances.

For further information including help text and usage, run:

```
tanzu service resource-claim list --help
```

To further interrogate the `ResourceClaim` for details, run:

```
tanzu service resource-claim get CLASS-NAME
```

Where `CLAIM-NAME` is the name of the `ResourceClaim` that currently is claiming the service instance.

Delete ResourceClaims

Application operators can unclaim a service instance on their target cluster by running:

```
tanzu service resource-claim delete CLAIM-NAME
```

Where `CLAIM-NAME` is the name of the `ResourceClaim` that currently claims the service instance.

For further information including help text and usage, run:

```
tanzu service resource-claim delete --help
```

Service offering

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Install

See the documentation about installing the latest release of Services Toolkit to get started.

Resources

ClusterResource

The `ClusterResource` CR is a place to store metadata regarding a Service Resource Lifecycle API. The only required field is `.spec.resourceRef`, which defines the Kubernetes API Group and Kind that a ClusterResource CR describes.

```
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterResource
metadata:
  name: rabbitmqcluster
```

```
  labels:
    # The following labels will be applied automatically by the ClusterResource contro
ller
    # to help with filtering and searching of ClusterResource resources
    services.apps.tanzu.vmware.com/api-group: rabbitmq.com
    services.apps.tanzu.vmware.com/api-kind: RabbitmqCluster
spec:
  # A reference to the Kubernetes API Group and Kind that this ClusterResource is desc
ribing
  resourceRef:
    # The Kubernetes API Group the resource belongs to
    group: rabbitmq.com
    # The Kubernetes API Kind of the resource
    kind: RabbitmqCluster
  # Short description of the resource (optional; string)
  shortDescription: "It's a RabbitMQ Cluster"
  # Long description of the resource (optional; string)
  longDescription: "RabbitMQ is an open source ..."
```

Note

Metadata stored in ClusterResource CRs is not specific to a particular version of the API. Version-specific API metadata is stored in GVKDescriptor CRs.

GVKDescriptor (duck type)

GVKDescriptor is not a concrete CRD itself, but rather a duck type of the following shape:

```
apiVersion: group/version
kind: Kind
spec:
  # A reference to the Kubernetes API Group/Version/Kind
  gvkRef:
    # The Kubernetes API Group the resource belongs to
    group: rabbitmq.com
    # The Kubernetes API Version of the API
    version: v1beta1
    # The Kubernetes API Kind of the resource
    kind: RabbitmqCluster
```

Any CR that contains `.spec.gvkRef` with the `group`, `version`, and `kind` fields can be considered a GVKDescriptor.

ClusterExampleUsage (GVKDescriptor)

`ClusterExampleUsage` CR adheres to the GVKDescriptor duck type and is used to store a YAML document for a Service Resource Lifecycle API.

```
apiVersion: services.apps.tanzu.vmware.com/v1alpha1
kind: ClusterExampleUsage
metadata:
  name: rabbitmqcluster-hello-world
  labels:
    # The following labels will be applied automatically by the ClusterExampleUsage co
```

```
ntroller
    # to help with filtering and searching of ClusterExampleUsage resources
    services.apps.tanzu.vmware.com/api-group: rabbitmq.com
    services.apps.tanzu.vmware.com/api-kind: RabbitmqCluster
    services.apps.tanzu.vmware.com/api-version: v1beta1
spec:
  # Adherence to GVKDescriptor duck type
  gvkRef:
    group: rabbitmq.com
    version: v1beta1
    kind: RabbitmqCluster
  # Description of the example
  description: |
    "Hello World" example for the RabbitmqCluster resource
  # YAML document for the example
  yaml: |
    ---
    apiVersion: rabbitmq.com/v1beta1
    kind: RabbitmqCluster
    metadata:
      name: hello-world
    spec:
      ...
```

Scope, Discoverability, and Usability

All Service Offering APIs are cluster-scoped. This means that, assuming relevant RBAC is configured, any user can get, list, and watch CRs from these APIs. This configuration helps to support discoverability, in that just as any user can run `kubectl api-resources` any user can also run `kubectl get clusterresources`. The former command outputs all API resources on the server, while the latter command outputs only the Service Resource Lifecycle APIs on the server (a subset).

Ability to discover Service Resource Lifecycle APIs does not mean a user has permission to use the APIs. Accessibility of a Service Resource Lifecycle API depends on whether the user has relevant RBAC permissions on the API that is discovered.

RBAC Rules for Discoverability

By default, the Services Toolkit carvel package allows the `system:authenticated` Group to get, list, and watch Service Offering resources by using the ClusterRole `service-offering-api-discoverability`.

Service API Projection and Service Resource Replication

Note

Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Install

See the documentation on installing the latest release of the Services Toolkit to get started and see Topology for information about supported topologies.

Concepts

This topic introduces a number of concepts. These are summarized as follows:

- Projection Plane
- API Projection
- Resource Replication

Projection Plane

Projection Plane defines an “upstream” and “downstream” relationship between a pair of Kubernetes clusters, namely between a Service Cluster (upstream) and a Workload Cluster (downstream).

UpstreamClusterLink and DownstreamClusterLink

The `UpstreamClusterLink` resource is created on a Service Cluster. Its main purpose is to manage a Service Account that components running in a Workload Cluster use.

```
apiVersion: projection.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: UpstreamClusterLink
metadata:
  name: workload-3c
  namespace: services-toolkit
spec:
  downstream:
    # Name of the Workload Cluster. This will be used for debugging.
    name: workload-3c
status:
  # Created Service Account that will be used by the Workload Cluster
  serviceAccount:
    name: managed-service-account
  observedGeneration: 1
  conditions:
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: Ready
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: ServiceAccountReady
```

The `DownstreamClusterLink` resource is created on a Workload Cluster. Its primary purpose is to manage an API aggregation server that is eventually used to project specific APIs. This resource:

- Contains information about the corresponding Service Cluster URL, name, CA certificate, and service account token.
- Deploys the API-aggregation server that is configured to proxy to the Service Cluster using the provided service account token.

```
apiVersion: projection.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
```

```
kind: DownstreamClusterLink
metadata:
  name: services-2b
  namespace: services-toolkit
spec:
  proxy:
    TLS:
      # TLS cert to be used for the API proxy
      secretName: omnia-isla
  upstream:
    kubeconfig:
      # Secret containing the kubeconfig to connect to the Service Cluster
      secretName: pumpkin-seeds
    name: services-2b
status:
  proxy:
    # base64-encoded CA for the API proxy
    caBundle: facade0ff1cebadc0ffee...
    # Reference to the kubernetes Service providing access to the API proxy
    serviceReference:
      name: services-2b-proxy
      namespace: services-toolkit
      port: 443
  conditions:
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: Ready
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: ServiceAccountReady
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: ProxyDeploymentReady
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: ProxyServiceReady
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: ProxyConfigMapReady
  - lastTransitionTime: "2021-02-02T18:41:22Z"
    status: "True"
    type: ProxyServiceAccountReady
```

The service account used by the proxy `Deployment` must have the following RBAC set up for it:

- A `ClusteRoleBinding` to the `system:auth-delegator` `ClusterRole` to delegate authentication decisions to the Kubernetes core API server.
- A `RoleBinding` to the `extension-apiserver-authentication-reader` role in the `kube-system` namespace. This allows your extension API-server to access the extension-apiserver-authentication configmap.
- A `ClusterRoleBinding` to a `ClusterRole` that provides `get`, `list`, and `watch` for namespaces. If such a `ClusterRole` doesn't exist, you must create one.

API Projection

API Projection makes custom Kubernetes APIs installed on a Service Cluster (upstream) available in a Workload Cluster (downstream).

APIExportRoleBinding

The purpose of the `APIExportRoleBinding` is to provide downstream users with necessary permissions on the Upstream Cluster. It does so by binding a user-specified `ClusterRole` to the service account referred to in the provided `UpstreamClusterLink` resource.

```
apiVersion: projection.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: APIExportRoleBinding
spec:
  upstreamClusterLinkRef:
    name: fish-sauce
    namespace: project-alpha
  clusterRoleRef:
    name: cluster-1-a
```

ClusterAPIGroupImport

The `ClusterAPIGroupImport` resource is a cluster-scoped resource created on the Workload Cluster. It expresses the intent to import an API group using the specified DownstreamClusterLink. Only one `ClusterAPIGroupImport` can exist per API Group.

After created, if a corresponding `APIExportRole` exists in the Service Cluster, a new custom Kubernetes API is available in the Workload Cluster and can be discovered by running the kubectl command `api-resources`.

```
apiVersion: projection.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: ClusterAPIGroupImport
metadata:
  name: rabbitmq.com
spec:
  # This is the reference to the DownstreamClusterLink resources
  downstreamClusterLinkRef:
    name: services-2b
    namespace: services-toolkit
  # The api group that is to be projected
  group: rabbitmq.com
  # Version of the api to be projected. Optional, if not specified register all discov
ered versions
  version: v1beta1
status:
  conditions:
  - type: Ready
    lastTransitionTime: "2020-12-01T13:03:32Z"
    status: "True"
  - type: APIServicesReady
    lastTransitionTime: "2020-12-01T13:03:28Z"
    status: "True"
```

APIResourceImport

The `APIResourceImport` resource is a namespace-scoped resource created on the downstream cluster. Its presence indicates to the proxy whether a projected Group and Resource is available in a namespace. The proxy uses this information to decide whether to forward a particular request upstream. This is for convenience rather than policy enforcement, which the RBAC achieves upstream.

Resources are specified at the namespace scope rather than the cluster scope to allow different resources to be made available in different namespaces.

```
apiVersion: projection.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: APIResourceImport
metadata:
  name: rabbitmq.com-import
  namespace: team-1 # namespace scoped resource as it sets up ns RBAC
 spec:
   clusterApiImportRef:
      name: rabbitmq.com
   resources: [“rabbitmqclusters”]
status:
  conditions:
  - type: Ready
    message: "Successfully reconciled"
    lastTransitionTime: "2020-12-01T13:03:30Z"
    status: "True"
  - type: ResourcesAvailable
    message: "Resources Ready"
    lastTransitionTime: "2020-12-01T13:03:32Z"
    status: "True"
```

Resource Replication

The resource replication components are responsible for synchronizing core Kubernetes resources across multiple clusters. As of version v0.5.0, the resource replication only handles the `Secret` resources.

SecretExport

`SecretExport` is a namespaced resource indicating that the named secret is involved in replication. Services Toolkit places these resources on the services cluster. This resource sets up permissions for the local service account, which the Workload Clusters use to pull the secret across.

```
apiVersion: replication.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: SecretExport
metadata:
  name: small-postgres-23.status.binding.name
  namespace: project-1
  labels:
    # The following labels will be applied automatically
    # to help with filtering and searching of SecretExport resources
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-group: sql.t
anzu.vmware.com
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-version: v1
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-kind: Postgr
es
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-name: small-
postgres-23
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-uid: cafe012
```

```
3d09e
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitor-binding-uid: 0ff1
ceca5cade
spec:
  secret:
    # The name of the secret in the current namespace to be replicated
    name: pg-binding
  serviceAccount:
    # The name of the service account in the current namespace that will be used for r
eplication
    name: upstream-replication-sa
```

SecretImport

`SecretImport` is responsible for replicating the secret from the Service Cluster. Services Toolkit places the `SecretImport` in a user namespace of the Workload Cluster for each secret. Currently, the namespace on the Service Cluster has to match the namespace on the Workload Cluster.

```
apiVersion: replication.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: SecretImport
metadata:
  namespace: project-1
  name: small-postgres-23.status.binding.name
  labels:
    # The following labels will be applied automatically
    # to help with filtering and searching of SecretImport resources
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-group: sql.t
anzu.vmware.com
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-version: v1
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-kind: Postgr
es
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-name: small-
postgres-23
    replication.apiresources.multicluster.x-tanzu.vmware.com/secret-owner-uid: cafe012
3d09e
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitor-binding-uid: 0b5e
55ed90dde55
spec:
  secret:
    # The name of the secret in the current namespace to be replicated
    name: dumbo
  remoteKubeconfig:
    # The name of a secret in the current namespace holding a kubeconfig for the Servi
ce Cluster
    name: energy-source
```

The two resources mentioned earlier handle a single `Secret` object replication. To set up replication of the specified secrets for every service instance of a given type, cluster-scoped resources `ClusterResourceImportMonitor` and `ClusterResourceExportMonitor` are used. Additionally, `ResourceImportMonitorBinding` and `ResourceExportMonitorBinding` are used to enable automatic replication in a namespace, and specify the connection details for replication for this namespace.

ClusterResourceImportMonitor

`ClusterResourceImportMonitor` is responsible for setting up watching on service instances. As a result, `SecretImport` resources can be produced when needed. `ClusterResourceImportMonitor` resources are defined on the Workload Cluster.

```
apiVersion: replication.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: ClusterResourceImportMonitor
metadata:
  name: postgres
  labels:
    # The following labels are required and must match the values in spec.resource
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitored-resource-group:
 sql.tanzu.vmware.com
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitored-resource-versio
n: v1
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitored-resource-kind:
Postgres
spec:
  # The type of the resource owning the secrets to be replicated
  resource:
    group: sql.tanzu.vmware.com
    version: v1
    kind: Postgres
  # The list of secrets to be replicated expressed as JSON path on the resource
  secretPaths:
  - .status.binding.name
```

ResourceImportMonitorBinding

By default, defining an `ClusterResourceImportMonitor` resource configures the resource type and secrets to be replicated, but does not enable replication. `ResourceImportMonitorBinding` enables the replication of secrets for service instances within a namespace. It references a secret containing the kubeconfig of the Service Cluster to pull the secrets from.

```
apiVersion: replication.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: ResourceImportMonitorBinding
spec:
  monitorRef:
    # Name of the related cluster-scoped ClusterResourceImportMonitor
    name: postgres
  remoteKubeconfig:
    # The name of a secret in the current namespace holding a kubeconfig for the Servi
ce Cluster
    name: energy-source
```

ClusterResourceExportMonitor

`ClusterResourceExportMonitor` is responsible for setting up watching on service instances, so that as a result, `SecretExport` resources can be produced when needed. `ClusterResourceExportMonitor` resources are defined on the services cluster.

```
apiVersion: replication.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: ClusterResourceExportMonitor
metadata:
  name: postgres
  labels:
```

```
    # The following labels are required and must match the values in spec.resource
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitored-resource-group:
 sql.tanzu.vmware.com
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitored-resource-versio
n: v1
    replication.apiresources.multicluster.x-tanzu.vmware.com/monitored-resource-kind:
Postgres
spec:
  # The type of the resource owning the secrets to be replicated
  resource:
    group: sql.tanzu.vmware.com
    version: v1
    kind: Postgres
  # The list of secrets to be replicated expressed as JSON path on the resource
  secretPaths:
  - .status.binding.name
```

ResourceExportMonitorBinding

By default, defining an `ClusterResourceExportMonitor` resource configures the resource type and secrets to be replicated, but does not enable replication. `ResourceExportMonitorBinding` enables the replication of secrets for service instances within a namespace. It provides the service account in the current namespace of the Service Cluster to pull the secrets from.

```
apiVersion: replication.apiresources.multicluster.x-tanzu.vmware.com/v1alpha1
kind: ResourceExportMonitorBinding
metadata:
  name: cluster1-postgres
  namespace: project-1
spec:
  monitorRef:
    # Name of the related cluster-scoped ClusterResourceImportMonitor
    name: postgres
  serviceAccount:
    # Name of the service account in the current namespace used by the Workload Cluste
r to pull secrets.
    name: upstream-replication-sa
```

Reference

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This section provides further references for Services Toolkit:

- Resource Requirements
- Known Limitations
- Supported Kubernetes Distributions
- Topology
- Terminology and User Roles
- Troubleshooting

Services Toolkit Terminology and User roles

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Terminology

Service

- A broad, high-level term used to describe something used in either the development of, or running of Application Workloads
- Often, but not exclusively, synonymous with the concept of a Backing Service as defined by The Twelve Factor App *… any service the app consumes over the network as part of its normal operation

Examples

- A PostgreSQL service (implemented as a Kubernetes Operator provided by Tanzu Data Services)

- A PostgreSQL service (implemented as a process running on an Application Developer's laptop)
- Object storage (implemented as SaaS running on AWS)
- AppSSO

Service Resource

- Any Kubernetes resource which provides (partial) functionality related to a Service

Examples

- A Kubernetes resource with API Kind `PostgreSQL`
- A Kubernetes resource with API Kind `FirewallRule`
- A Kubernetes resource with API Kind `RabbitmqUser`
- A Kubernetes resource with API Kind `ClientRegistration` providing access to an App SSO service
- A Kubernetes resource with API Kind `Secret` containing credentials and connectivity information for a Service (which may or may not be running on the cluster itself)

Provisioned Service

- This term is defined in the Service Binding Specification for Kubernetes.
    - Essentially, any Service Resource which defines a `.status.binding.name` which points to a Secret in the same namespace containing credentials and connectivity information for the resource
- See Provisioned Service for the full definition.

Service Binding

- A mechanism in which Service Instance credentials and other related connectivity information are communicated to Application Workloads in an automated way

Examples

- The Service Binding concept implemented through the `ServiceBinding` Service Resource provided by https://github.com/vmware-tanzu/servicebinding

Service Instance

- An abstraction over one or a group of interrelated Service Resources that together provide the expected functionality for a particular service
- One of the Service Resource that make up an Instance must either adhere to Provisioned Service or be a Secret conforming to the Service Binding Specification for Kubernetes
    - This guarantees that Service Instances can be Claimed and subsequently bound to Application Workloads
- Service Instances are made discoverable through Service Instance Classes

Examples

- The `RabbitmqCluster` Service Resource provided by the RabbitMQ Cluster Operator
  - This Service Resource adheres to Provisioned Service, as such any `RabbitmqCluster` resource on a Kubernetes cluster could be considered a Service Instance
- A logical grouping of the following Service Resources could be said to form a single “AWS RDS” Service Instance:
  - An AWS RDS `DBInstance`
  - An AWS RDS `DBSubnetGroup`
  - A Carvel `SecretTemplate` configured to produce a Secret conforming to the Service Binding Specification for Kubernetes
  - A `Role`, `RoleBinding` and `ServiceAccount`
- A Kubernetes `Secret` conforming to the Service Binding Specification for Kubernetes containing credentials for a Service running external to the cluster

Service Instance Class

- Provides a way to describe “classes” (i.e. categories) of Service Instances
- Allows for discovery of Service Instances belonging to the class
- Refers to a pool of Service Instances
- Different classes might map to different Services or to different configurations of the same Service

Examples

- A `ClusterInstanceClass` named “rabbitmq-dev” pointing to all `RabbitmqCluster` Service Resources configured with `.spec.replicas=1` identified by label `class: rmq-dev`
- A `ClusterInstanceClass` named “rabbitmq-prod” pointing to all `RabbitmqCluster` Service Resources configured with `.spec.replicas=3` identified by label `class: rmq-prod`
- A `ClusterInstanceClass` named “aws-rds-postgresql” pointing to Secrets conformant with the Binding Specification and identified by label `class: aws-rds`

Resource Claim

- A mechanism in which requests for Service Instances can be declared and fulfilled without requiring detailed knowledge of the Service Instances themselves

Examples

- The Resource Claim concept implemented through the `ResourceClaim` Service Resource provided by Services Toolkit

Claimable Service Instance

- Any Service Instance which is permitted to be claimed via a Resource Claim from a namespace, taking into consideration:
  - Location (namespace) of the Service Instance in relation to the location (namespace) of the Resource Claim
  - Any matching Resource Claim Policies
  - Exclusivity of Resource Claims (i.e. a given instance can only be claimed once at a time)

Examples

- A `RabbitmqCluster` Service Resource residing in the same namespace as a Resource Claim and which has not already been claimed by another Resource Claim could be said to be a "Claimable Service Instance"
- A `RabbitmqCluster` Service Resource residing in a different namespace to a Resource Claim, for which a matching Resource Claim Policy exists, and for which has not already been claimed by another Resource Claim could be said to be a "Claimable Service Instance"
- A `RabbitmqCluster` Service Resource residing in the same namespace as a Resource Claim which has already been claimed could not be said to be a "Claimable Service Instance" due to the exclusive nature of Resource Claims

Service Resource Lifecycle API

- Any Kubernetes API that can be used to manage the life cycle (CRUD) of a Service Resource

Examples

- `rabbitmqclusters.rabbitmq.com/v1beta1`

Service Cluster

- Applicable within the context of Service API Projection and Service Resource Replication
- A Kubernetes cluster that has Service Resource Lifecycle APIs installed and a corresponding controller managing their life cycle

Workload Cluster

- Applicable within the context of Service API Projection and Service Resource Replication
- A Kubernetes cluster that has developer-created applications running on it

User Roles

Services Toolkit caters to the following user roles.

It is important to note that these User Roles are not User Personas - it is perfectly possible (and even expected) that one human being could be associated with many User Roles at any given time. The User Roles align to Tanzu Application Platform's User Roles, and the Services Toolkit team is primarily responsible for defining the Service Operator role.

The User Roles listed here consist of a short description as well as the Jobs To Be Done for the role. For detailed information on corresponding RBAC associated with each role, please refer to Detailed role permissions breakdown.

Application Developer (AD)

Encompasses both app-editor and app-viewer roles as defined by Tanzu Application Platform

Jobs To Be Done

- Bind and unbind Application Workloads to/from Resource Claims
- Get, List, Watch ResourceClaims
- Get, List, Watch ClusterInstanceClasses associated with ResourceClaims

Application Operator (AO)

Encompasses the app-operator role as defined by Tanzu Application Platform

Jobs To Be Done

- Discover and learn about Service Instance Classes available on a cluster
- Discover Claimable Service Instances associated with Service Instance Classes
- Lifecycle management (CRUD) of Resource Claims

Service Operator (SO)

Jobs To Be Done

- Lifecycle management (CRUD) of Service Instances
- Lifecycle management (CRUD) of Service Instance Classes
- Lifecycle management (CRUD) of Resource Claim Policies
- Identify pending Resource Claims and, if deemed appropriate, help to fulfil such claims through a combination of the above Jobs To Be Done

Known limitations

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic lists known limitations and issues with Services Toolkit.

Service Resource Replication Limitations

Service Resource Replication limitations are listed as follows.

Updates to `Secrets` are not replicated

Currently, after a `Secret` is replicated from a Service Cluster to a Workload Cluster, any further updates to the original `Secret` in the Service Cluster are not propagated to the replica `Secret` in the Workload Cluster. VMware aims to remove this limitation in a future release of Services Toolkit.

Service API Projection Limitations

Service API Projection limitations are listed as follows.

Unable to project Core Kubernetes APIs

API projection via does not work with core Kubernetes APIs such as Secrets. This means that use cases such as Direct Service References or Cloud Service Provider use cases, support such as Consuming AWS RDS on TAP, will not work when combined with usage of the `kubectl-scp` plugin as shown in Dedicated Service Clusters.

CRD and Aggregation layer conflict

VMware uses api-aggregation as the mechanism to project APIs. After an API is registered by using this aggregation layer (the APIService is available), even if you create a CRD pointing to the same path, the aggregation layer still proxies the requests. If you do it the other way around, first create the CRD and then “project” the API (or register the APIService). That way the APIService is not available.

Local CRD is created before Service Resource API is projected

For example, you create `rabbitmqclusters.rabbitmq.com/v1beta1` on your workload cluster by creating a `CustomResourceDefinition` before projecting the `rabbitmq.com/v1beta1` API. When you try to project the `rabbitmq.com/v1beta1` API, the APIService `v1beta1.rabbitmq.com` is not ready.

`rabbitmqclusters.rabbitmq.com` CRD status:

```
status:
  acceptedNames:
    categories:
    - all
    kind: RabbitmqCluster
    listKind: RabbitmqClusterList
    plural: rabbitmqclusters
    shortNames:
    - rmq
    singular: rabbitmqcluster
  conditions:
  - lastTransitionTime: "2021-08-18T13:01:31Z"
    message: no conflicts found
    reason: NoConflicts
    status: "True"
    type: NamesAccepted
  - lastTransitionTime: "2021-08-18T13:01:31Z"
    message: the initial names have been accepted
```

```
    reason: InitialNamesAccepted
    status: "True"
    type: Established
  storedVersions:
  - v1beta1
```

`rabbitmq.com-v1beta1-api-group-import` ClusterAPIGroupImport status:

```
status:
  conditions:
  - lastTransitionTime: "2021-08-18T13:01:47Z"
    message: apiservices.apiregistration.k8s.io "v1beta1.rabbitmq.com" already exists
    reason: APIServiceNotReady
    status: "False"
    type: APIServiceReady
  - lastTransitionTime: "2021-08-18T13:01:47Z"
    message: apiservices.apiregistration.k8s.io "v1beta1.rabbitmq.com" already exists
    reason: APIServiceNotReady
    status: "False"
    type: Ready
  observedGeneration: 1
```

To use Service API Projection on your cluster when you don't have any Custom Resources provisioned from this CRD, delete the local CRD and delete/recreate the ClusterAPIGroupImport.

When local CRD is created after Service Resource API is projected

When local CRD is created after Service Resource API is projected, the APIService is available but the `rabbitmqclusters.rabbitmq.com` CRD does not show any errors on the status. This can be confusing as when you provision or delete a Custom Resource because the requests are proxied and run on the linked Service cluster, not on your local cluster.

`rabbitmqclusters.rabbitmq.com` CRD status:

```
status:
  acceptedNames:
    categories:
    - all
    kind: RabbitmqCluster
    listKind: RabbitmqClusterList
    plural: rabbitmqclusters
    shortNames:
    - rmq
    singular: rabbitmqcluster
  conditions:
  - lastTransitionTime: "2021-08-18T09:40:35Z"
    message: no conflicts found
    reason: NoConflicts
    status: "True"
    type: NamesAccepted
  - lastTransitionTime: "2021-08-18T09:40:35Z"
    message: the initial names have been accepted
    reason: InitialNamesAccepted
    status: "True"
    type: Established
  storedVersions:
  - v1beta1
```

`rabbitmq.com-v1beta1-api-group-import` ClusterAPIGroupImport status:

```
status:
  conditions:
  - lastTransitionTime: "2021-08-18T13:10:48Z"
    status: "True"
    type: APIServiceReady
  - lastTransitionTime: "2021-08-18T13:10:48Z"
    status: "True"
    type: Ready
  observedGeneration: 1
```

No built-in support for cluster-scoped requests against projected APIs in the Workload Cluster

By default, Services Toolkit does not support projection of cluster-scoped requests in the Workload Cluster. It supports namespace-scoped requests only.

This poses a problem with certain controllers watching these APIs in the Workload Cluster, for example, Service Binding implementation in GitHub. They might require cluster-scoped read access verbs on projected APIs in the Workload Cluster.

There is a workaround for these types of scenarios:

VMware provides a ClusterRole by using the `kubectl-scp` plug-in's `federate` command on the Service Cluster.

For example:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: "example"
rules:
- apiGroups:
    - rabbitmq.com
  resources:
    - rabbitmqcluster
  verbs: ["get", "list", "watch"]
```

The ClusterRole is then bound to the Proxy Service Account on the Service Cluster.

This workaround has significant implications:

- It represents a potential attack vector in which a malicious user operating in Workload Cluster A might obtain the secret access token used by the Proxy and, in turn, use that token to perform read actions (e.g. get/watch/list) on resources in the Service Cluster that are owned by an entirely different Workload Cluster B. In other words, this workaround circumvents proper isolation of projected resources between different Workload Clusters.
- It's confusing to the App Operator who might see resources that belong to non-existing namespaces.
- Projected resources belonging to a Workload Cluster A are potentially being leaked to users in Workload Cluster B. It's similar to the security issue stated earlier in this list, but different in

that the user doesn't even have to have any sort of malicious intent.

Future versions of the Services Toolkit add first-class support for cluster-scoped requests against projected APIs and, therefore, remove the need for the laid out workaround and its problematic characteristics.

Service Resource Claims Limitations

Service Resource Claims limitations are listed as follows.

Can only claim service resources that adhere to the Kubernetes Binding specification

Currently, a `ResourceClaim` is only successful in claiming a service resource if that service resource adheres to the Provisioned Service duck type in GitHub or if directly referring to a compatible secret. Future iterations of Services Toolkit might loosen this requirement by using an extension of the `ResourceClaim` function or another API.

Can only claim service resources once

Currently, only a single `ResourceClaim` can successful claim a service resource. If a second `ResourceClaim` is created for the same service resource, it fails with `ResourceAlreadyClaimed`. Future iterations of Services Toolkit might allow shared service resources.

Resource requirements

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic describes the resources required to install and use Services Toolkit.

> **Note**
>
> At present it is not possible to alter default resource configurations for Services Toolkit as part of installation.

Deployments

To better understand resource requirements and use, consider the various Kubernetes deployments that are created as part of installation, and subsequent use of Services Toolkit.

Upon installation of Services Toolkit to a cluster, a single Deployment named `services-toolkit-controller-manager` is created and it defines a container with the following resource configuration:

```
resources:
  limits:
```

```
      cpu: 200m
      memory: 500Mi
    requests:
      cpu: 100m
      memory: 100Mi
```

> **Note**
>
> See the Kubernetes documentation for further information about resource management in Kubernetes.

For each `DownstreamClusterLink` resource created as part of configuring a Projection Plane (see Service API Projection and Service Resource Replication), one additional `Deployment` is created on the downstream cluster. This `Deployment` defines a container with the following resource configuration:

```
resources:
  limits:
    cpu: 100m
    memory: 100Mi
  requests:
    cpu: 100m
    memory: 20Mi
```

There is one additional `Deployment` for each `ClusterResourceExportMonitor` and `ClusterResourceImportMonitor` resource that is created upon configuration of Resource Replication (see Service API Projection and Service Resource Replication). This `Deployment` defines a container with the following resource configuration:

```
resources:
  limits:
    cpu: 100m
    memory: 100Mi
  requests:
    cpu: 100m
    memory: 20Mi
```

Therefore, the minimum set of resources required to support the federation of an API between a Workload Cluster and a Service Cluster is as follows:

- Workload Cluster
  - 1 x Services Toolkit controller manager deployment
  - requests 100m CPU and 100Mi memory
  - 1 x API proxy deployment
  - requests 100m CPU and 20Mi memory
  - 1 x ClusterResourceImportMonitor deployment
  - requests 100m CPU and 20Mi memory
- Service Cluster

- 1 x Services Toolkit controller manager deployment
- requests 100m CPU and 100Mi memory
- 1 x ClusterResourceExportMonitor deployment
- requests 100m CPU and 20Mi memory

- Total minimum resource requirements
  - Workload Cluster = 300m CPU and 140Mi memory
  - Service Cluster = 200m CPU and 120Mi

> **Note**
>
> Services Toolkit does not require the use of volumes or any external storage.

Supported Kubernetes distributions

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Kubernetes Distribution	GA Functionality Tested?	Experimental / Beta Functionality Tested?
kind	Yes (used for our local development)	Yes
GKE	Yes (continuously tested in CI)	Yes
AKS	Yes	Not yet
EKS	Yes	Not yet
VMware Tanzu Kubernetes Grid (TKGm) clusters	Yes (TKGm v1.5.0 on vSphere)*	Not yet
Other	Unknown - we haven’t tested Services Toolkit on other distributions yet, but it should** work.	Unknown

* TKGm 1.5+ is required.

** Services Toolkit leverages core Kubernetes APIs to provide function, therefore, in most case, it is compatible with most reasonably up-to-date distributions.

Topology

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

Topology is a combination of Service and Workload Clusters, their namespaces and the Service Resource Lifecycle APIs that are to be made available from Service Clusters to one or more Workload Clusters.

The following two assumptions that must hold true for topologies currently supported by the Services Toolkit.

- The presence of a “flat” network is assumed, which is to say that workloads running in one cluster can establish network connections (resolution and routing) to the Kubernetes API Server endpoints of all other clusters without any additional setup.
- Application workloads can establish network connections to the endpoints of service instances without any additional setup.

Supported Topologies

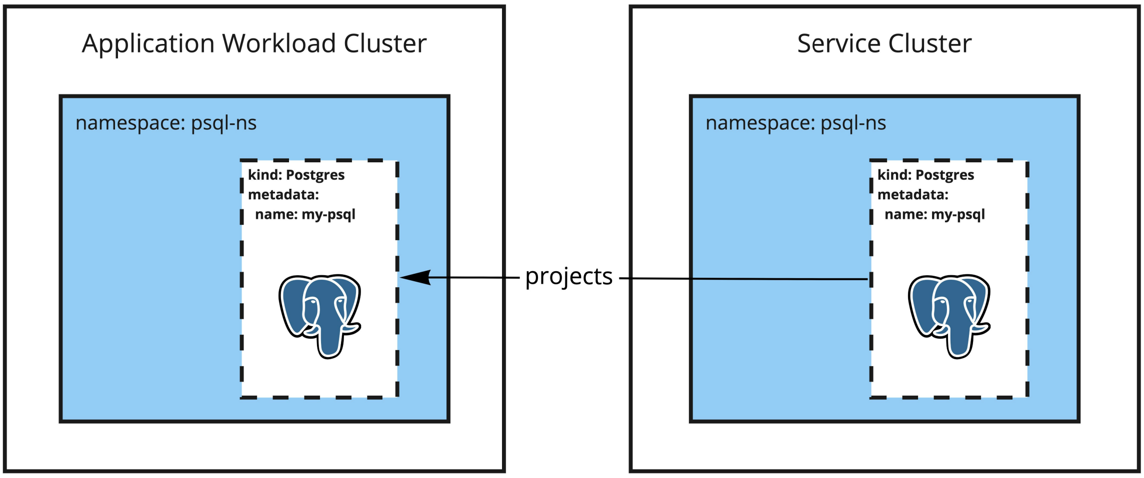
Topologies currently supported by Service Toolkit have the following rules:

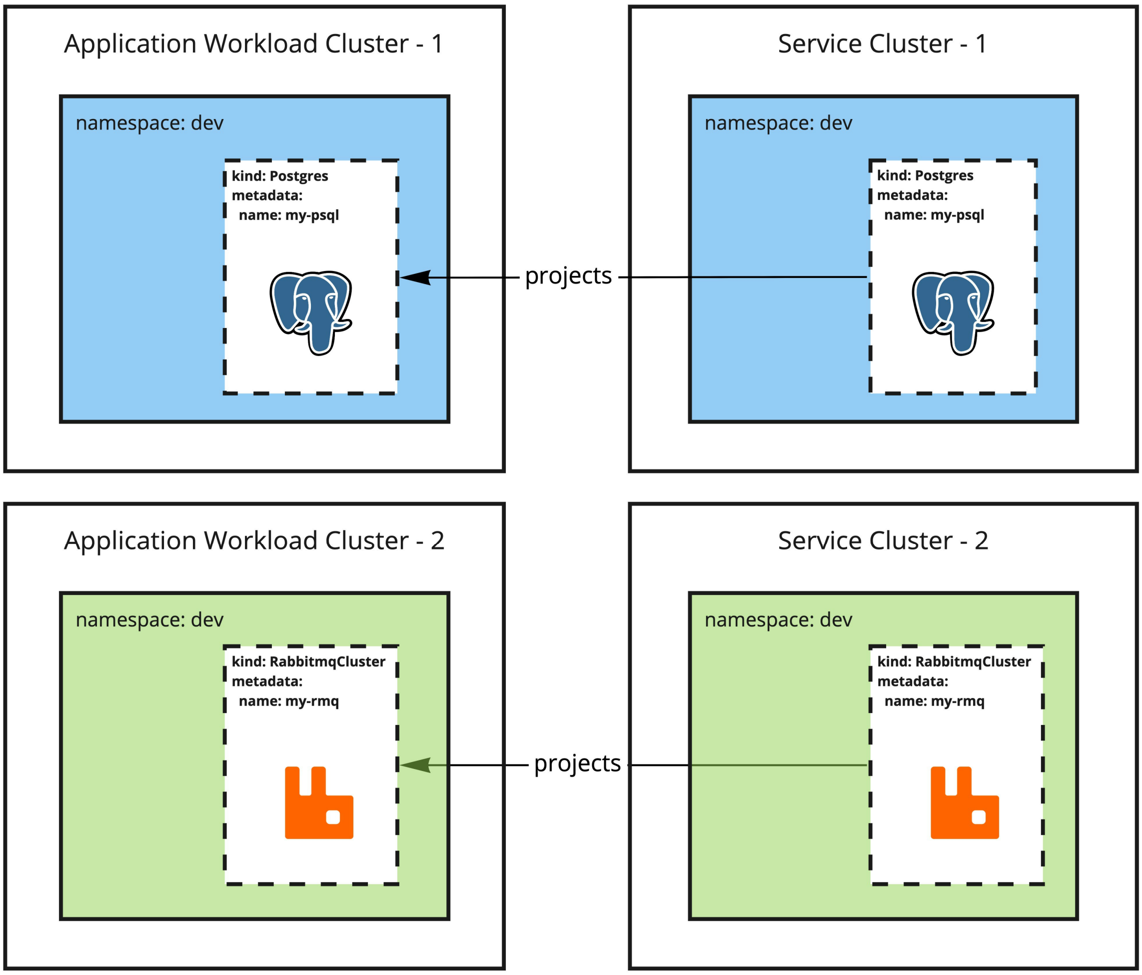
- API Projection does not work within a single cluster but only across a set of distinct service and workload clusters.
- An API group can be either projected into a cluster or installed/reconciled within that cluster, not both. For example, you cannot install the RabbitmqCluster Operator and project `RabbitmqCluster` resources from a Service cluster in the same Workload cluster. See Limitations for further details.
- Resources of a projected API group must exist in identically named namespaces in the workload and service clusters. For a workload cluster, there can only be a single service cluster for a API group projection. For example, a workload cluster cannot receive projections of a RabbitmqCluster API from service cluster 1 and from service cluster 2.

Provide a Service Resource Lifecycle API

From one Service cluster to one Workload cluster

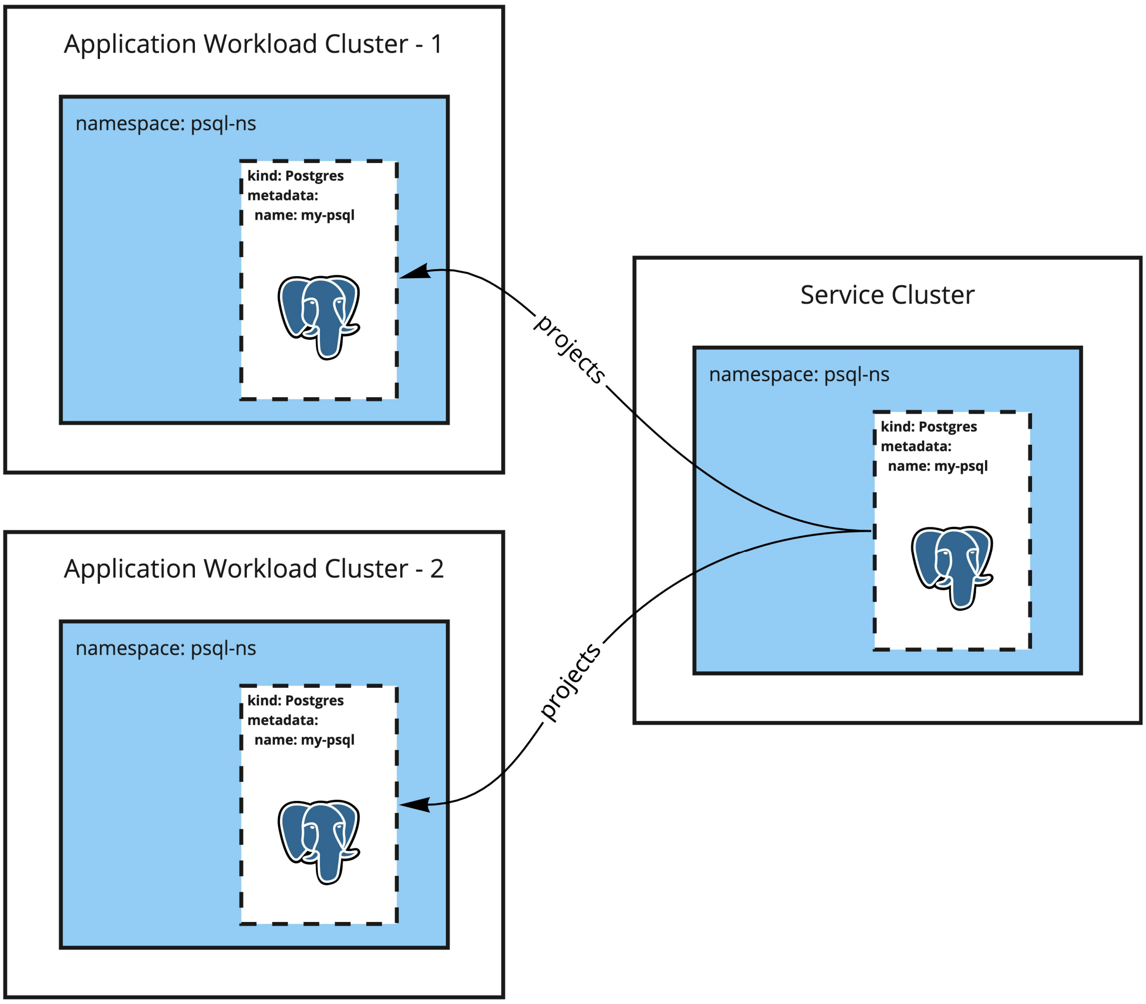
Service Operator wants to provide a Service Resource Lifecycle API from one service cluster to one workload cluster in the same named namespace.





From a Service cluster to multiple Workload clusters

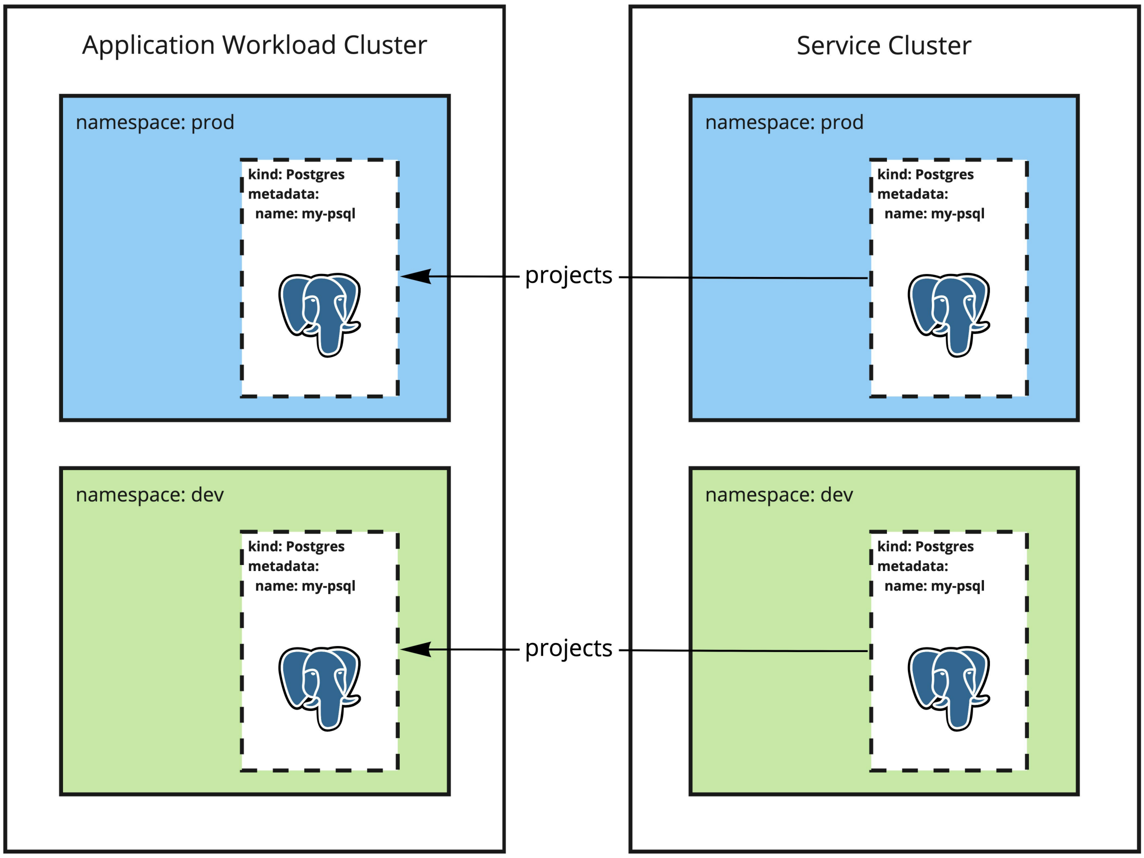
Service Operator wants to provide a Service Resource Lifecycle API from a Service cluster to multiple Workload clusters with the same named namespace.



Provide different Service Resource Lifecycle APIs

From a Service cluster to a Workload cluster

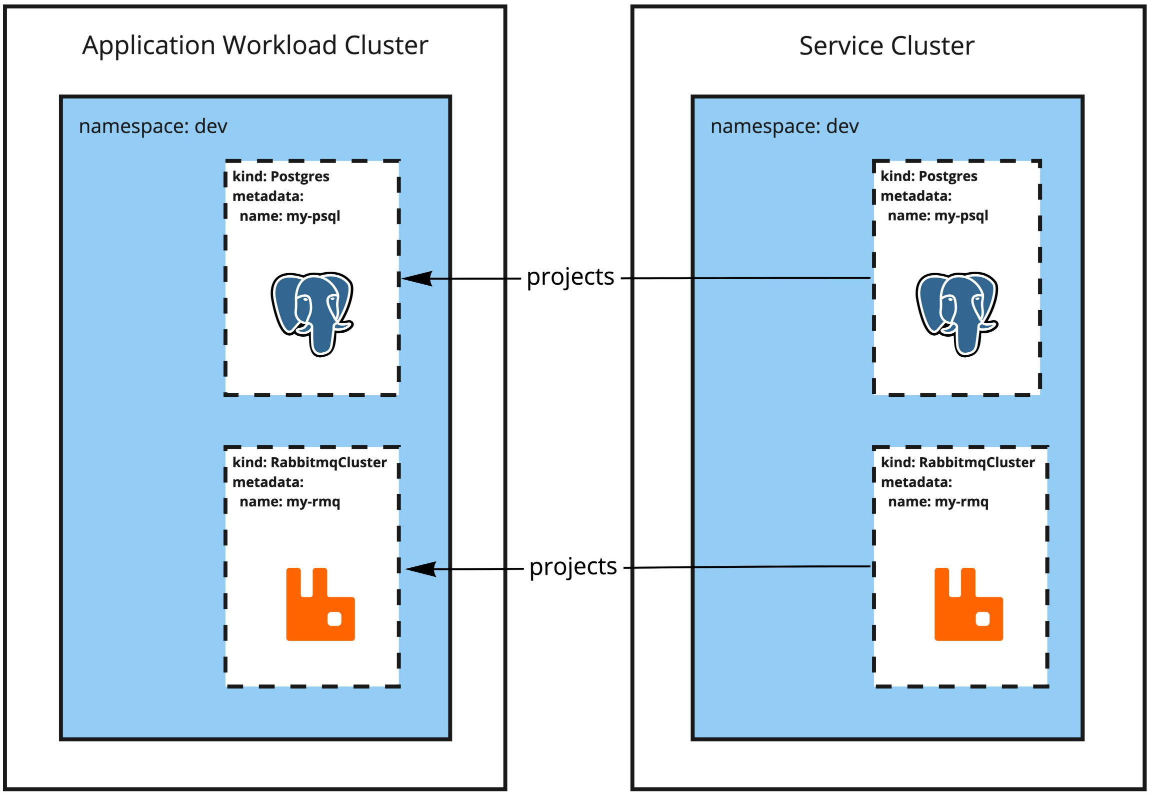
Service Operator wants to provide different Service Resource Lifecycle APIs from one Service cluster and distinct namespaces to one Workload cluster in matching named namespaces.



Provide multiple Service Resource Lifecycle APIs

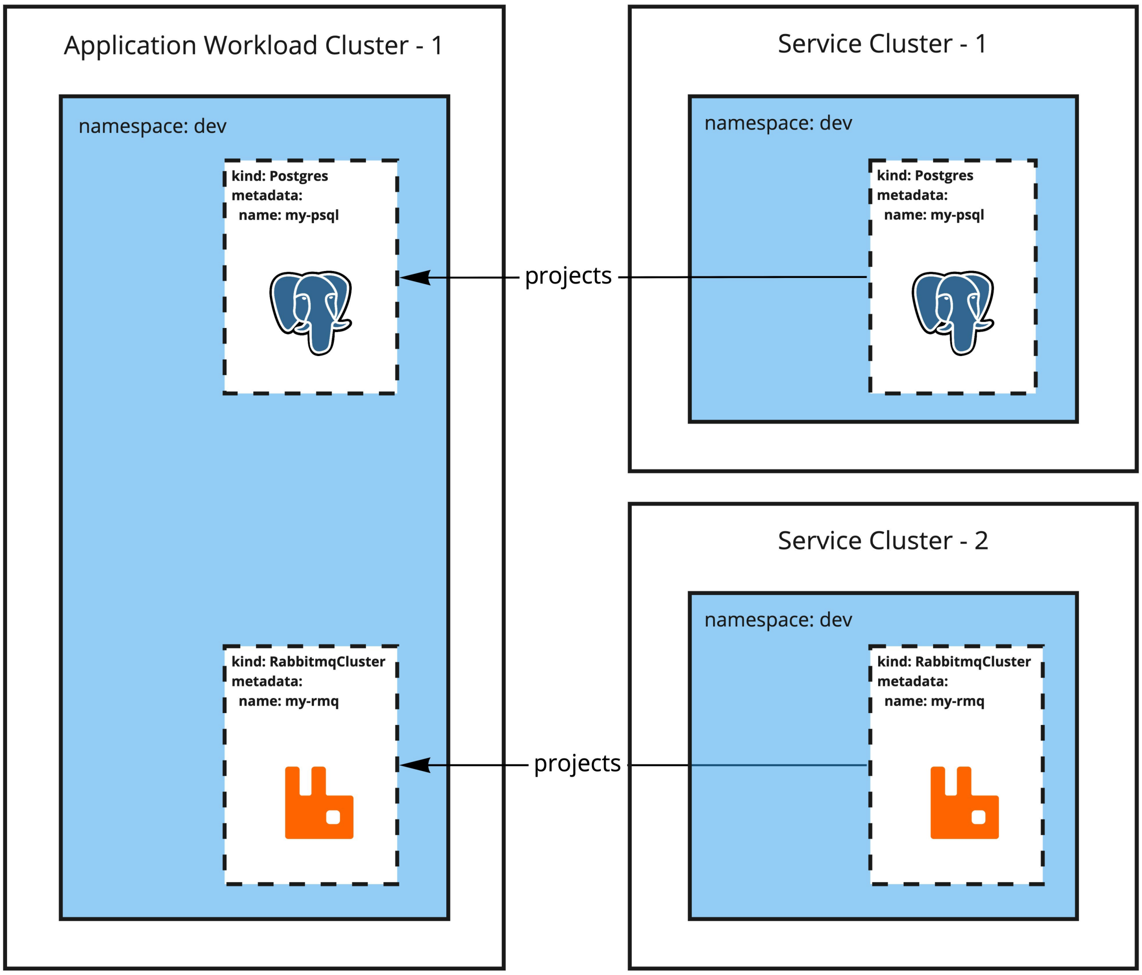
From a Service Cluster to a Workload cluster

Service Operator wants to provide multiple Service Resource Lifecycle APIs from one Service Cluster and one namespace to one Workload cluster with the same named namespace.



From multiple Service Clusters to one Workload cluster

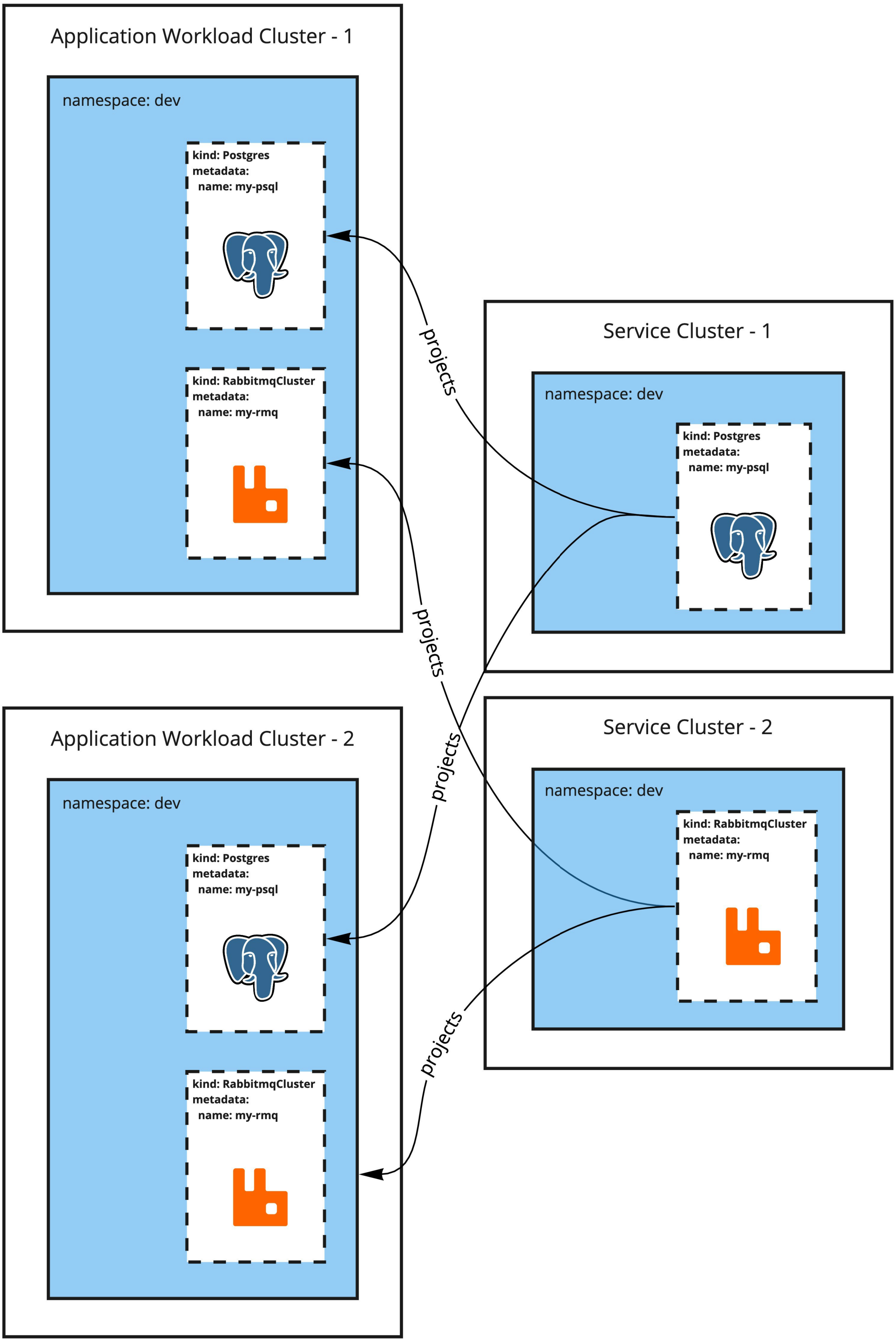
Service Operator wants to provide multiple Service Resource Lifecycle APIs from multiple Service Clusters with the same namespace to one Workload cluster with the same named namespace.



Caution: In this particular scenario, you might encounter name collisions in the application workload clusters for the core resources such as secrets. For example, if API-1 creates a secret called `binding-secret` and API-2 also creates a secret called `binding-secret`, Resource Replication component copies both of these secrets in the application workload cluster, but one is overridden by the other depending on which one is replicated second.

From multiple service clusters to multiple workload clusters

Service Operator wants to provide multiple Service Resource from multiple distinct Service Clusters with the same namespace name to multiple Workload clusters with matching named namespace.



Troubleshooting

> **Note**
>
> Starting with the Services Toolkit v0.10 release, you can find the Services Toolkit documentation in the Tanzu Application Platform v1.5 and later documentation.

This topic provides information for debugging and resolving issues with Services Toolkit.

Logs

Services Toolkit contains a single controller deployment. All logs related to Services Toolkit are on this deployment. The logs are in JSON format. You can obtain the logs by running:

```
kubectl logs -l app.kubernetes.io/name=services-toolkit-controller-manager -n services
-toolkit
```

This is a sample of a log entry:

```
{
  "level": "info",
  "ts": 1639042469.5265353,
  "logger": "controller.resourceclaim",
  "msg": "Starting workers",
  "reconciler group": "services.apps.tanzu.vmware.com",
  "reconciler kind": "ResourceClaim",
  "worker count": 1
}
```

Inspecting Resources

Services Toolkit is comprised of a number of API endpoints, the majority of which are Custom Resource Definitions (CRDs). These resources configure and drive the behavior of Services Toolkit and contain the state of the system. A complete list of the APIs with how to obtain them for inspection follows.

Service Resource Claims

- resourceclaims.services.apps.tanzu.vmware.com
- resourceclaimpolicies.services.apps.tanzu.vmware.com
- clusterinstanceclasses.services.apps.tanzu.vmware.com
- instancequeries.claimable.services.apps.tanzu.vmware.com

Service Offerings

- clusterresources.services.apps.tanzu.vmware.com
- clusterexampleusages.services.apps.tanzu.vmware.com

Service API Projection - Experimental

- downstreamclusterlinks.projection.apiresources.multicluster.x-tanzu.vmware.com

- upstreamclusterlinks.projection.apiresources.multicluster.x-tanzu.vmware.com
- apiexportrolebindings.projection.apiresources.multicluster.x-tanzu.vmware.com
- apiresourceimports.projection.apiresources.multicluster.x-tanzu.vmware.com
- clusterapigroupimports.projection.apiresources.multicluster.x-tanzu.vmware.com

Service Resource Replication - Experimental

- clusterresourceexportmonitors.replication.apiresources.multicluster.x-tanzu.vmware.com
- clusterresourceimportmonitors.replication.apiresources.multicluster.x-tanzu.vmware.com
- resourceexportmonitorbindings.replication.apiresources.multicluster.x-tanzu.vmware.com
- resourceimportmonitorbindings.replication.apiresources.multicluster.x-tanzu.vmware.com
- secretexports.replication.apiresources.multicluster.x-tanzu.vmware.com
- secretimports.replication.apiresources.multicluster.x-tanzu.vmware.com

For example, to find all `ResourceClaims` in all namespaces you can run:

```
kubectl get resourceclaim -A
```

Common issues

ResourceClaim errors with `UnableToTrackReferencedResource`

- **Symptom:** A `ResourceClaim` is not functioning and running `kubectl get ResourceClaim <name>` shows error `UnableToTrackReferencedResource`.
- **Cause:** This is due to the controller being unable to access (`list` or `watch`) the resource.
- **Resolution:** Verify that the name of the Resource referenced in the `ResourceClaim`'s `.spec.ref` exists on the cluster and ensure RBAC exists to allow claiming is enabled. See ResourceClaims Permissions documentation.

ResourceClaim errors with `ResourceNonBindable`

- **Symptom:** A `ResourceClaim` is not working and running `kubectl get ResourceClaim <name>` shows error `ResourceNonBindable`.
- **Cause:** This is due to the Resource not adhering to the k8s-binding-spec `Provisionable` duck-type.
- **Resolution:** Ensure that the Resource CRD implements the `Provisionable` type and was created successfully.

Unable to discover services using `tanzu service` plug-in

Warning: `tanzu service types list` and `tanzu service instances list` are deprecated commands. It is advised to make use of `tanzu service classes list` and `tanzu service claimable list` instead.

- **Symptom:** `tanzu service types list` returns `no service types found` or `tanzu service instances list` return `no service instances found`.
- **Cause:** There are no `ClusterResource` resources on the cluster, or there are no resources matching one of the referenced Service Types in a `ClusterResource` resource. It could be both.
- **Resolution:** Create one or more `ClusterResource` resources, referencing the APIs to make discoverable. Create one or more resources matching the API Group/Kind referenced in a created `ClusterResource` resource. For more information, see Service offering for VMware Tanzu.

Permission error running `tanzu service instances list`

Warning: `tanzu service instances list` is a deprecated command. Use `tanzu service classes list` and `tanzu service claimable list` instead.

- **Symptom:** Running `tanzu service instances list` returns a 401 permission error.
- **Cause:** The user running the command does not have sufficient RBAC permissions to get or list resources matching the API Group/Kinds defined in created ClusterResource resources.
- **Resolution:** Ensure sufficient RBAC for all users for all resources that are referenced in ClusterResource resources that are installed on the cluster. This is a manual step required to be taken by a Service Operator upon installing a new service. For example, RabbitMQ and making it discoverable.

Updates to a claimed secret do not propagate to the Workload

- **Symptom:** An update to a claimed secret is not reflected in the workload using it. This can be because of password rotation or something similar.
- **Cause:** While the secret was updated in the pod, because the secret is mounted there, the application still needs to re-read it. Many don't do that.
- **Resolution:** Restart the pods so that when the application starts up, it re-reads the updated mounted secret. If the pods scale to 0 because a Knative service manages them, they also re-read the secret on a scale-up.