Microsoft

Kubernetes Technical Briefing

Module 3:
Intermediate Kubernetes Topics

Agenda

- Volumes and Persistence
- Multi-Container Pods
- Init Containers
- Jobs and Cron Jobs
- Daemon Sets
- Health Probes
- Ingress
- Helm Package Manager

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Volumes and Persistence

Kubernetes Volumes

- Deleting or restarting a POD destroys any persistent data stored in the containers file system.
- *Ephemeral* volume types have a lifetime of a pod, but *persistent* volumes exist beyond the lifetime of a pod.
- At its core, a volume is a directory, possibly with some data in it, which is accessible to the containers in a Pod.
  - Azure Disk -> /mnt/external
- A Pod can use any number of volume types simultaneously.

Ephemeral Volumes

- *Ephemeral* volume types have a lifetime of a pod. Ephemeral volumes include:
- **Empty Dir** – A temporary folder for all containers within a Pod to read/write to.
- **Host Path** – Mounts a file or directory from the host node's filesystem into your Pod. Not practical in a multi-node cluster.
- **Config Map/Secret** – A Read-only folder that provides a way to inject configuration data into pods.

```yaml
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    volumeMounts:
    - name: tempVol
      mountPath: /usr/share/nginx/html
      readOnly: true
    - name: hostVal
      mountPath: /usr/home/somefile
  volumes:
  - name: tempVol
    emptyDir: {}
  - name: hostVal
    hostPath:
      path: /var/local/aaa/1.txt
      type: FileOrCreate
```

Persistent Volumes

- *Persistent* volumes exist beyond the lifetime of a pod. Persistent volumes include:
- **Azure Disk** – Mounts an Azure Data Disk into a pod.
- **Azure File** – Mounts an Azure File Share (SMB 2.1/3.0) to a Pod.
- **Persistent Volume Claim** - A way for users to "claim" durable storage without knowing the details of the cloud environment.

```
    volumeMounts:
    - name: shareVol
      mountPath: /usr/share/nginx/html
    - name: diskVol
      mountPath: /usr/data
  volumes:
    - name: shareVol
      azureFile:
        secretName: azure-storage
        shareName: data
        readOnly: false
    - name: diskVol
      azureDisk:
        kind: Managed
        diskName: tempdisk2
        diskURI: "/subscriptions/aa82959
```

Persistent Volumes

- A **PersistentVolume** (PV) resource is a piece of storage in the cluster that has been provisioned by an administrator or dynamically provisioned using **Storage Classes**.
- PVs are volume plugins like Volumes but have a lifecycle independent of any individual Pod that uses the PV.
- It is a cluster wide resource (not namespaced), available to for any user to claim.
- There are two ways PVs may be provisioned:
  - **Statically** - A cluster administrator creates multiple PVs that carry the details of the real storage, which is available for use by cluster users.
  - **Dynamically** - When none of the available static PVs match a user's Persistent Volume Claim, the cluster will try to dynamically provision a volume specially for the PVC, based on a specified Storage Classes.

Static Persistent Volume Claims

- Once a **PersistentVolume** has been created, it can be claimed by a **PersistentVolumeClaim.** The PVC can then be mounted as a volume in the Pod.

```yaml
apiVersion: v1
kind: PersistentVolume
metadata:
  name: task-pv-volume
  labels:
    usage: file-storage
spec:
  capacity:
    storage: 10Gi
  accessModes:
    - ReadWriteMany
  persistentVolumeReclaimPolicy: Retain
  azureFile:
    secretName: azure-storage
    shareName: data
    readOnly: false
```

```yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: file-storage-claim
  annotations:
    volume.beta.kubernetes.io/
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 5Gi
  selector:
    matchLabels:
      usage: file-storage
```

```yaml
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    volumeMounts:
      - name: html
        mountPath: /usr/share/nginx/html
        readOnly: false
  volumes:
    - name: html
      persistentVolumeClaim:
        claimName: file-storage-claim
```

- This is an example of a *Statically* provisioned **PersistentVolumeClaim**.

Dynamic Persistent Volume Claims

- A **PersistentVolumeClaim** can also be provisioned dynamically by specifying the **StorageClass** (wrapper around driver) to use when creating the PVC.

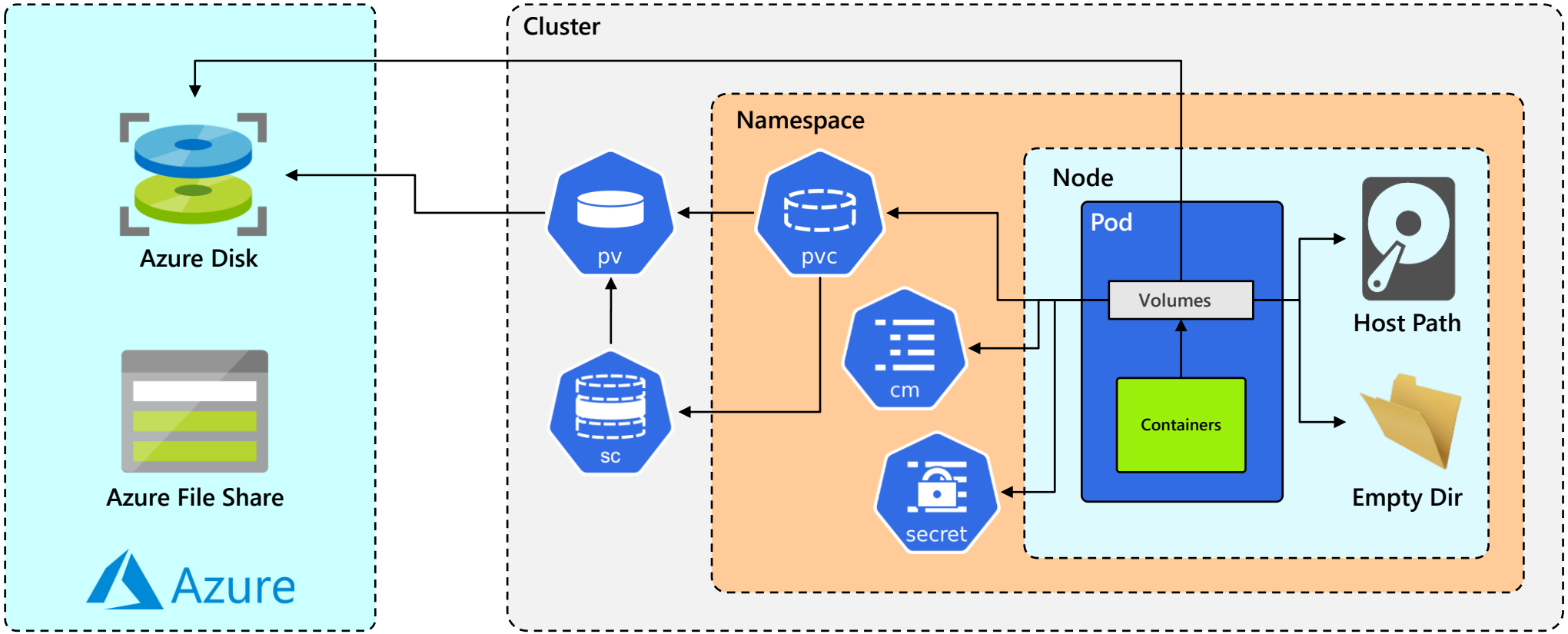
```yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: file-storage-claim
spec:
  accessModes:
    - ReadWriteMany
  storageClassName: azurefile-premium
  resources:
    requests:
      storage: 10Gi
```

```yaml
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    volumeMounts:
      - name: html
        mountPath: /usr/share/nginx/html
        readOnly: false
  volumes:
    - name: html
      persistentVolumeClaim:
        claimName: file-storage-claim
```

- A storage account is automatically created in the *infrastructure resource group* for use with the storage class to hold the Azure file shares.
- **NOTE:** If the cluster is deleted (like cattle), all the resources in the *infrastructure resource group*, including dynamically provisioned file shares and disks, will also be deleted.

Overview of Kubernetes Volumes

Kubernetes offers many flexible options for mounting volumes into Pods.



Volumes Demo

Working with Volumes

Persistent Volume with Multiple Pod Replicas

- A ***PersistentVolume*** can be mounted on a host in any way supported by the resource provider.
- Scaling a Deployment introduces the problem persistent volumes across multiple Pod replicas.
- What happens when multiple Pods, on different Nodes, attempt to access the same Persistent Volume?

Advanced Persistent Volumes Demo

Working with Persistent Volumes when Scaling Pods

Persistent Volume Access Modes

- Persistent Volumes support the following ***Access Modes***, which determine how multiple Pods mount the same volume:
  - **ReadWriteOnce (RWO)** – Mount a volume as read-write by a single node.
  - **ReadOnlyMany (ROX)** – Mount the volume as read-only by many nodes.
  - **ReadWriteMany (RWX)** – Mount the volume as read-write by many nodes.
- While the ***ReadWriteMany*** access mode would allow multiple Pods to share a volume across multiple Nodes, most external volume providers do not support this functionality.

```yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: file-storage-claim
spec:
  accessModes:
    - ReadWriteMany
  storageClassName: azurefile
  resources:
    requests:
      storage: 10Gi
```

Volume Plugin	ReadWriteOnce	ReadOnlyMany	ReadWriteMany
AWSElasticBlockStore	✓	-	-
AzureFile	✓	✓	✓
AzureDisk	✓	-	-
CephFS	✓	✓	✓
Cinder	✓	-	-

Multi-Container Pods

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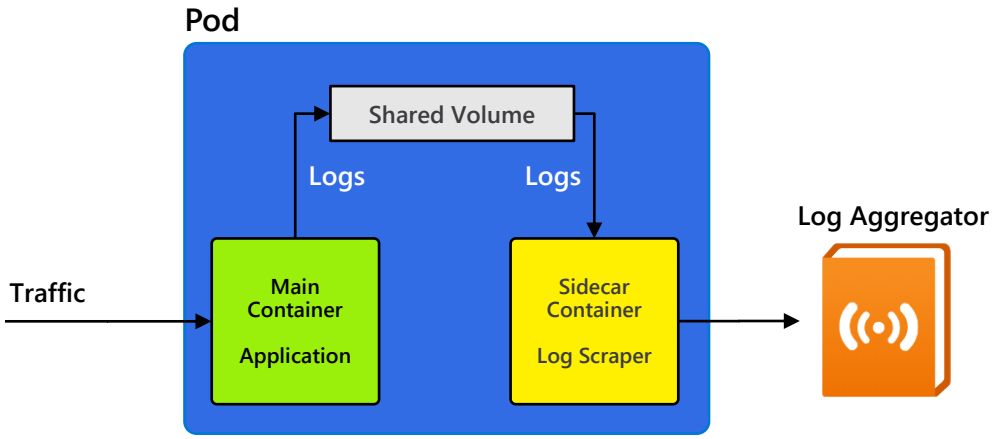
Keep Highly Coupled Containers Together

- As a rule, most Pods only contain a single container. However, there are times when it makes sense to put multiple, related containers inside a single Pod.
- Containers running in a Pod share the same IP, port and communicate using native inter-process communication channels (localhost).
- Containers in a Pod also share the same lifecycle and are scaled together.
- When one container fails, the status of the Pod changes to a non-running state, which prevents other containers from receiving traffic.
- Pods *Restarts* count is the total number of restarts of all its containers.
- Only highly-coupled related containers (those that interact with each other frequently) should be placed in the same Pod.

Sidecar Pattern

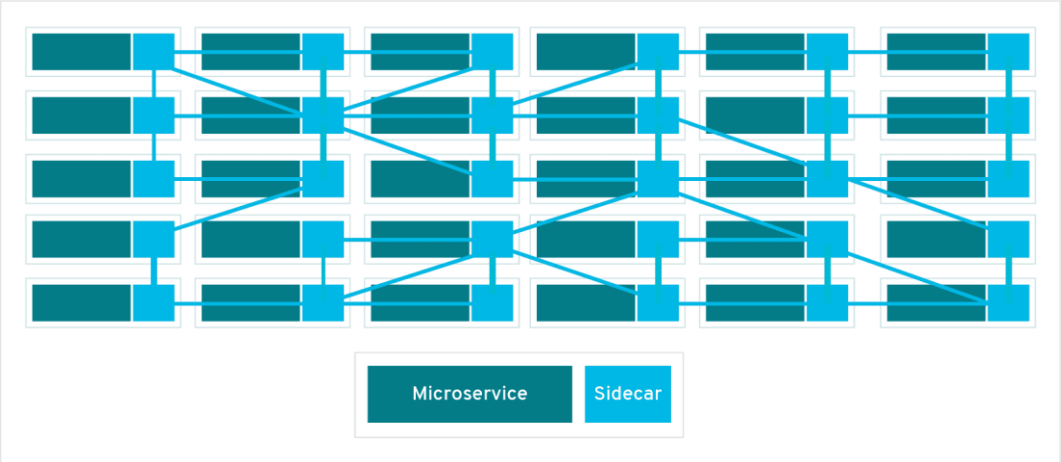
- A common scenario for using multiple container in a Pod is to implement the *Sidecar Pattern*.
- A Sidecar container is a second container added to the Pod definition because it needs to access the same resources being used by the main container.




```yaml
spec:
  volumes:
    - name: shared-logs
      emptyDir: {}
  containers:
    - name: nginx
      image: nginx
      volumeMounts:
        - name: shared-logs
          mountPath: /var/log/nginx
    - name: sidecar-container
      image: busybox
      command: ["sh","-c","while true;
      volumeMounts:
        - name: shared-logs
          mountPath: /var/log/nginx
```

Sidecar Envoy Proxy

- The Envoy Proxy project implements the Sidecar pattern by *automatically injecting* an Envoy container into *every* Pod in a namespace.
- Such a system is called a *Service Mesh*.
- Service meshes provide microservices support services like:
  - Dynamic service discovery
  - Load balancing
  - Health checks
  - Encryption
  - Circuit breakers
  - Authentication/Authorization
  - Observability and Rich metrics



- Istio, Linkerd and Microsoft's Open Service Mesh are popular service meshes.

Multi-Container Pods Demo

Working with Multi-Container Pods

Init Containers

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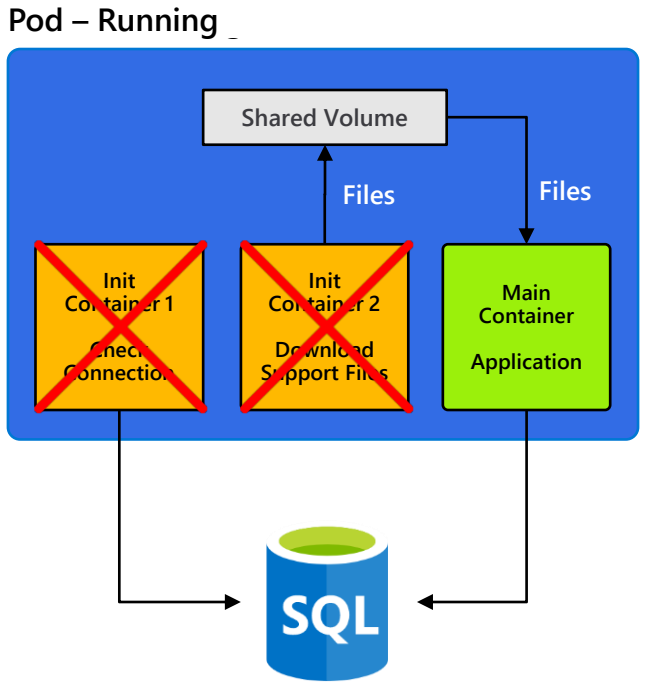
Init Containers

- Sometimes containerized applications require dependencies (like external databases connection) to be available before they can start.
- Some applications can't start until costly initialization steps are performed.
- Rather then adding initialization logic to every application, the process can be delegated to a separate *initialization* container.
  - Such an *init container* runs once before the main container is created
  - If initialization is successfully, the *init container* is deallocated and the main container is created.
  - If initialization fails, the Pod will keep restarting the *init container*. None of the main containers will be created until this step completes.
  - If multiple *init containers* are specified, each one is *run one at a time, in the order they're defined in the spec*, until they all complete successfully.
  - After Pod startup, *init containers* are not listed as part of the Pod container inventory.

Running Init Containers

- Creating and running ***init*** containers is part of the Pod start up process.
- Pods do not reach a *Running* state until this process is completed successfully.




```yaml
spec:
  initContainers:
  - name: homepage
    image: busybox
    args:
    - "/bin/sh"
    - "-c"
    - "wget -O /work-dir/index.html http://neverssl.com/online;
    volumeMounts:
    - name: tempvol
      mountPath: /work-dir # internal mount path
  containers:
  - name: nginx
    image: nginx
    volumeMounts:
    - name: tempvol
      mountPath: /usr/share/nginx/html
```

Init Containers Demo

Working with Init Containers

Jobs and Cron Jobs

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Container Restart Policy

- When Kubernetes controller detects a container has failed, it will attempt to restart it based on the container's ***restartPolicy***:
  - Always
  - Never
  - OnFailure
- A *Deployment* controller expects Containers to run continuously (think of a web server or database server always listening for requests/queries).
- The only *restart policy* a Deployment supports is ***Always***.
- Sometimes, you may want to run a Container that performs a finite task and then just stop.
- Just like an *Init Container*, but without creating any other Containers afterwards.

Jobs

- A ***Job*** is a Kubernetes controller that creates and runs task-based workload.
- A **Job** creates a Pod, whose Container(s) is expected to execute *once*, run for a *short period of time* and then *stop*.
- When the Container ends its processing, the Pod goes into a *Completed* state.
- A **Job** can specify that multiple Pods be created (**completions**) and how many Pods should be created at the same time (**parallelism**).
- Containers defined in a Job only support ***Never*** and ***OnFailure*** restart policies.

```yaml
apiVersion: batch/v1
kind: Job
...
spec:
  completions: 10
  parallelism: 4
  backoffLimit: 3
  activeDeadlineSeconds: 100
  template:
    metadata:
      name: countdown-multi
      labels:
        app: countdown-multi
    spec:
      containers:
      - name: counter
        image: centos:7
        command:
          - "bin/bash"
          - "-c"
          - "for i in 3 2 1 ; do
      restartPolicy: OnFailure
```

CronJobs

- A ***CronJob*** is a Kubernetes controller that creates and manages ***Jobs*** according to a *cron* schedule.
- ***CronJobs*** are useful for creating periodic and recurring tasks, like running backups or sending emails.
- ***CronJobs*** maintain a certain number of successful and failed jobs, so their logs can be examined.
- When a ***CronJob*** deletes a Job, that Job's Pods are deleted.

```
apiVersion: batch/v1beta1
kind: CronJob
...
spec:
  schedule: "*/1 * * * *"
  successfulJobsHistoryLimit: 2
  failedJobsHistoryLimit: 2
  jobTemplate:
    spec:
      completions: 10
      parallelism: 4
      template:
      ...
        spec:
          containers:
          - name: hello
            image: busybox
            args:
            - /bin/sh
            - -c
            - date; echo Hello from
            - sleep 2
          restartPolicy: OnFailure
```

Jobs and CronJobs Demo

Working With and Scheduling Jobs

Daemon Sets

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Daemon Sets

- ***DaemonSets*** are controllers that ensure new Nodes run an instance of a Pod.
- As nodes are added to the cluster, Pods are scheduled on them automatically.
- As nodes are removed from the cluster, those Pods are terminated.
- Most system ***DaemonSets*** create Pods that can tolerate any taint.
- Some typical uses for a ***DaemonSet*** are:
  - Running a cluster storage daemon on every node
  - Running a logs collection aggregator
  - Running a node monitoring agent on every node (Ex: omsagent for *Azure Monitor*).
  - Running a CSI Secrets provider (Ex: azure-secrets-provider for Azure *Key Vault*)

DaemonSets Demo

Exploring System DaemonSets

Health Probes

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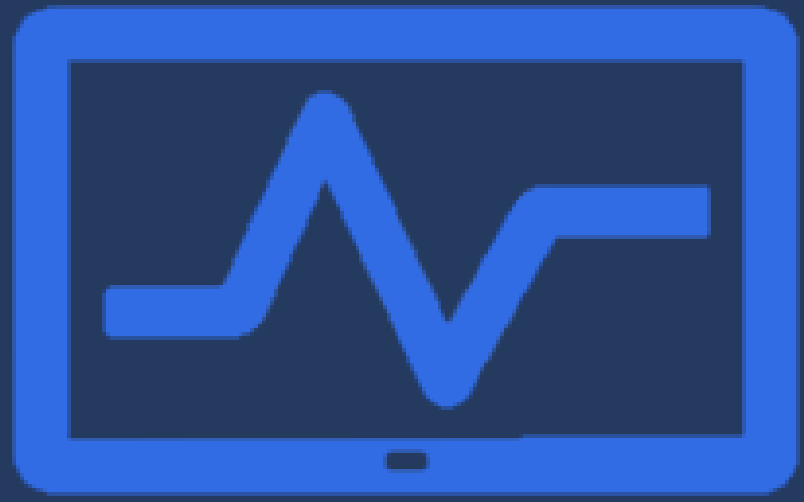

Health Checks

- How do you know if a container has completed its start up sequence and is ready to accept requests?
- What if a container is “running” but not functioning correctly?
  - For example, a webserver not receiving/processing requests
- Kubelet uses ***probes*** to monitor running containers and determine if they’re running and/or can receive traffic from services.
- Based on information it receives from probes, a Kubelet can restart containers or notify Kube-proxy to update its Endpoints and take Pods out of a service’s load balancer rotation.

Startup, Liveness and Readiness Probes

- There are three different types of probes available to attach to containers:
  - **Startup Probe** – Detects when an application has started. Some applications, like messaging servers, have extended startup sequences. Startup probes delay other probes from inadvertently telling the *Kubelet* restart the container for being unresponsive.
  - **Liveness Probe** – Once the application has started, a liveness probe monitors it periodically to ensure it's still running and tell the *Kubelet* to restart the container if it doesn't get a response.
  - **Readiness Probe** – Applications which service external requests, through a Service, can be monitored to ensure they are still receiving those requests. When they stop receiving requests, Readiness Probes can tell the *Kubelet* to exclude those pods from the service's load balancer rotation.

```yaml
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    startupProbe:
      tcpSocket:
        port: 80
      failureThreshold: 30
      periodSeconds: 10
    livenessProbe:
      httpGet:
        path: /healthy
        port: 80
      failureThreshold: 1
      periodSeconds: 10
    readinessProbe:
      tcpSocket:
        port: 80
      initialDelaySeconds: 5
      timeoutSeconds: 2
      periodSeconds: 10
```

Health Probes Demo

Using Health Probes to Monitor Containers

Ingress

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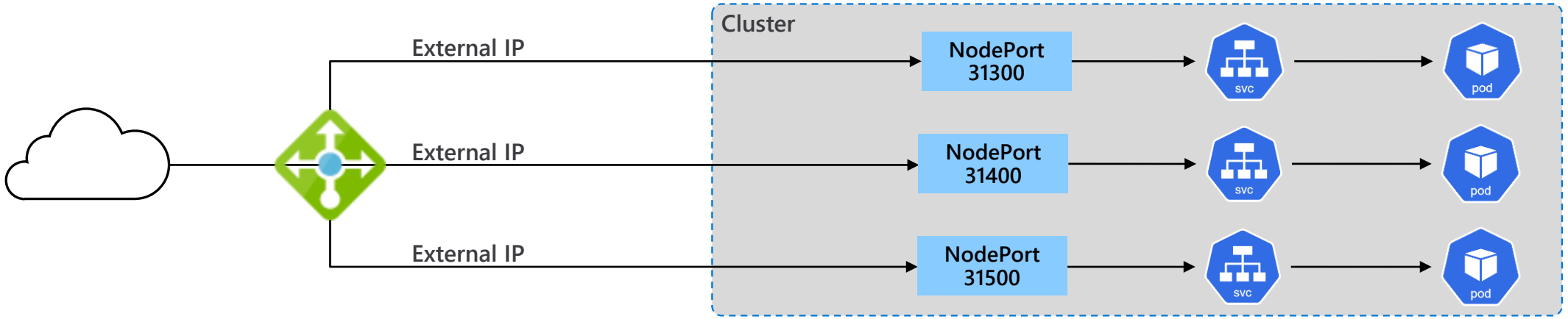
Kubernetes Load Balancer vs Ingress

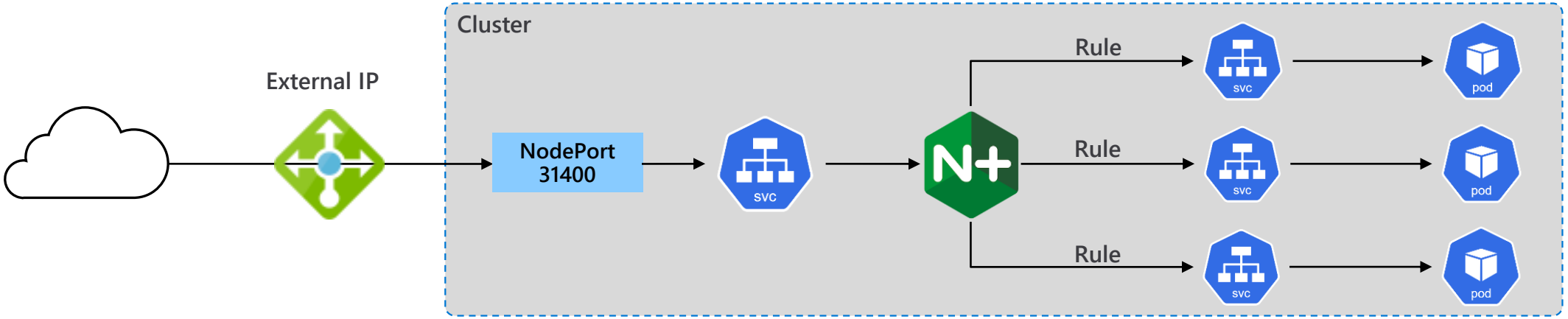
A Kubernetes Load Balancer maps an external IP to a single service endpoint inside the cluster.



- Each Kubernetes Load Balancer service requests an external IP address from Azure.
- For multiple service endpoints, you need to create multiple Load Balancers and IPs.
- If you expose dozens or hundreds of endpoints, this approach doesn't scale well.

Kubernetes Load Balancer vs Ingress

An ***Ingress*** Resource enables routing to internal traffic through a single external endpoint.



- Routing rules are defined in ***Ingresses*** in each namespace.
- A single ***Ingress Controller*** combines Ingress rules across all namespaces and routes external HTTP and HTTPS (layer 7 only) traffic to internal ***Cluster IP*** services.
- Kubernetes does not provide a concrete implementation of an ***Ingress Controller*** to perform this routing.

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-wildcard-host
spec:
  rules:
  - host: "*.foo.com"
    http:
      paths:
      - pathType: Prefix
        path: "/foo"
        backend:
          serviceName: service2
          servicePort: 80
      - pathType: Prefix
        path: "/xyz"
        backend:
          serviceName: service4
          servicePort: 4053
```

3rd Party Ingress Controller

- To support ***Ingress*** resources, you must install a 3rd party ***Ingress Controller***.
- Kubernetes supports the following popular Ingress Controllers:
  - The NGINX Ingress Controller for Kubernetes works with the NGINX webserver (as a proxy).
  - The Traefik Kubernetes Ingress provider is an ingress controller for the Traefik proxy.
  - The AKS Application Gateway Ingress Controller is an ingress controller that configures the Azure Application Gateway.

Ingress Controller Demo

Working with Ingress Resource and Ingress Controllers

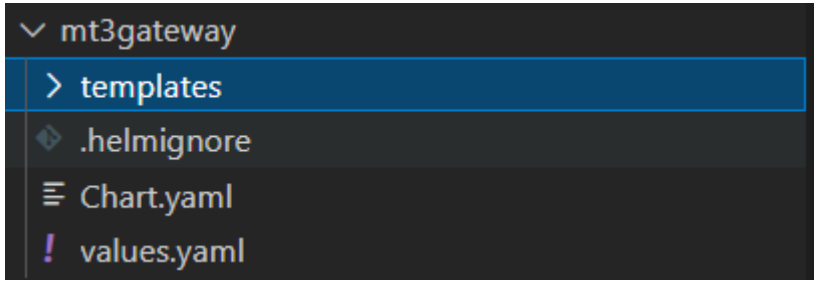
Helm Package Manager

Helm Package Manager

- Helm is a package manager for Kubernetes-based applications.
- Helm ***Charts*** help you define, install, and upgrade even the most complex Kubernetes application.
- Charts are easy to create, version, share, and publish.
- Helms can package and preconfigure Kubernetes applications into charts, which allow you to:
  - Manage and share your own application chart packages
  - Leverage other popular software packaged as charts
  - Create reproducible builds of Kubernetes applications
  - Manage you Kubernetes manifest files
- You can Push and Pull Helm charts to Azure Container Registries.

A Helm Chart Manages an Entire Application

- Helm streamlines installing/upgrading applications
  - Perform consistent releases without dealing with dozens of files
  - Update/rollback releases - as needed.
- A Helm **Chart** consists of:
  - A **Chart.yaml** file containing metadata about the chart
  - An optional **values.yaml** file containing parameters you can use in Kubernetes *manifest* files
  - Parameters can be used for substitutions or in macros.
  - A **templates** folder containing your manifest files.




```yaml
apiVersion: v2
appVersion: "1.0"
description: A Helm chart for Math Trick
name: mathtrick3gateway
version: 0.1
```

Chart.yaml

```yaml
repo: kizacr.azurecr.io
namespace: gateway
platform: dotnet
tags:
  mt3gatewayweb: latest
  mt3gatewaygateway: latest
```

values.yaml

```yaml
spec:
  containers:
  - name: mt3chained-step1
    image: {{ .Values.repo }}/mt3chained
    ports:
```

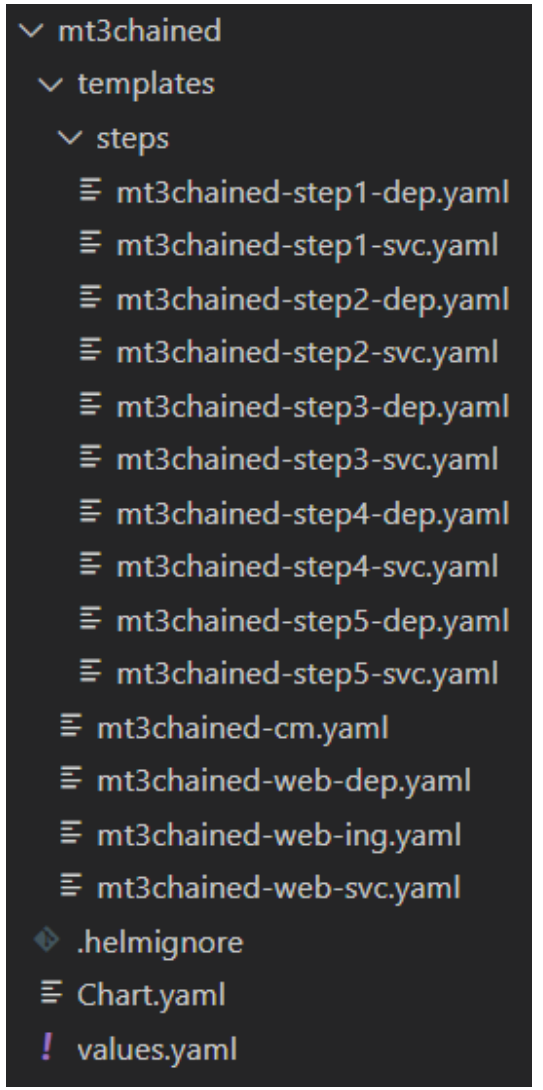
mt3chained-step1-dep.yaml

A Helm Chart Contains the Manifests

- The **templates** folder contains all application related manifest files.
- Sub-folder structure under templates doesn't matter to Helm. You can organize your manifest files as desired.
- The **helm** command is used to manage charts:

```
helm [command] [release name] [chart name] [flags]
```

- **Command** - Specifies the operation that you want to perform. Some valid commands include ***install***, ***upgrade***, ***ls***, ***uninstall***.
- **Release Name** - Specifies the name you want to give to the release. This is just for management purposes.
- **Chart Name** – Specifies the name of the chart you want to install/upgrade. Can be a folder name for a local chart or package name for an external chart.
- **Flags** – Optional flags.



Helm Examples

- **Example**: Install a local chart in the *mychart* folder, giving it a release name of *demo*. Use the **-set** flag to override a parameter specified in the **values.yaml** file

```
helm install demo mychart --set repo=myrepo.azurecr.io
```

- **Example**: Apply any changes to manifests files by upgrading a previously installed chart

```
helm upgrade demo mychart
```

- **Example**: Adds a reference to the *scubakiz* external helm repo and installs the *clusterinfo* chart from that repo.

```
helm repo add scubakiz https://scubakiz.github.io/clusterinfo/
helm install clusterinfo scubakiz/clusterinfo
```

- **Example**: Upgrades an existing chart (or installs it if it doesn't exist) with the parameters specified in an alternate ***values.staging.yaml*** file

```
helm upgrade --install demo mychart -f values.staging.yaml
```

- **Example**: Uninstalls a previously installed chart. All resources in *templates* are deleted.

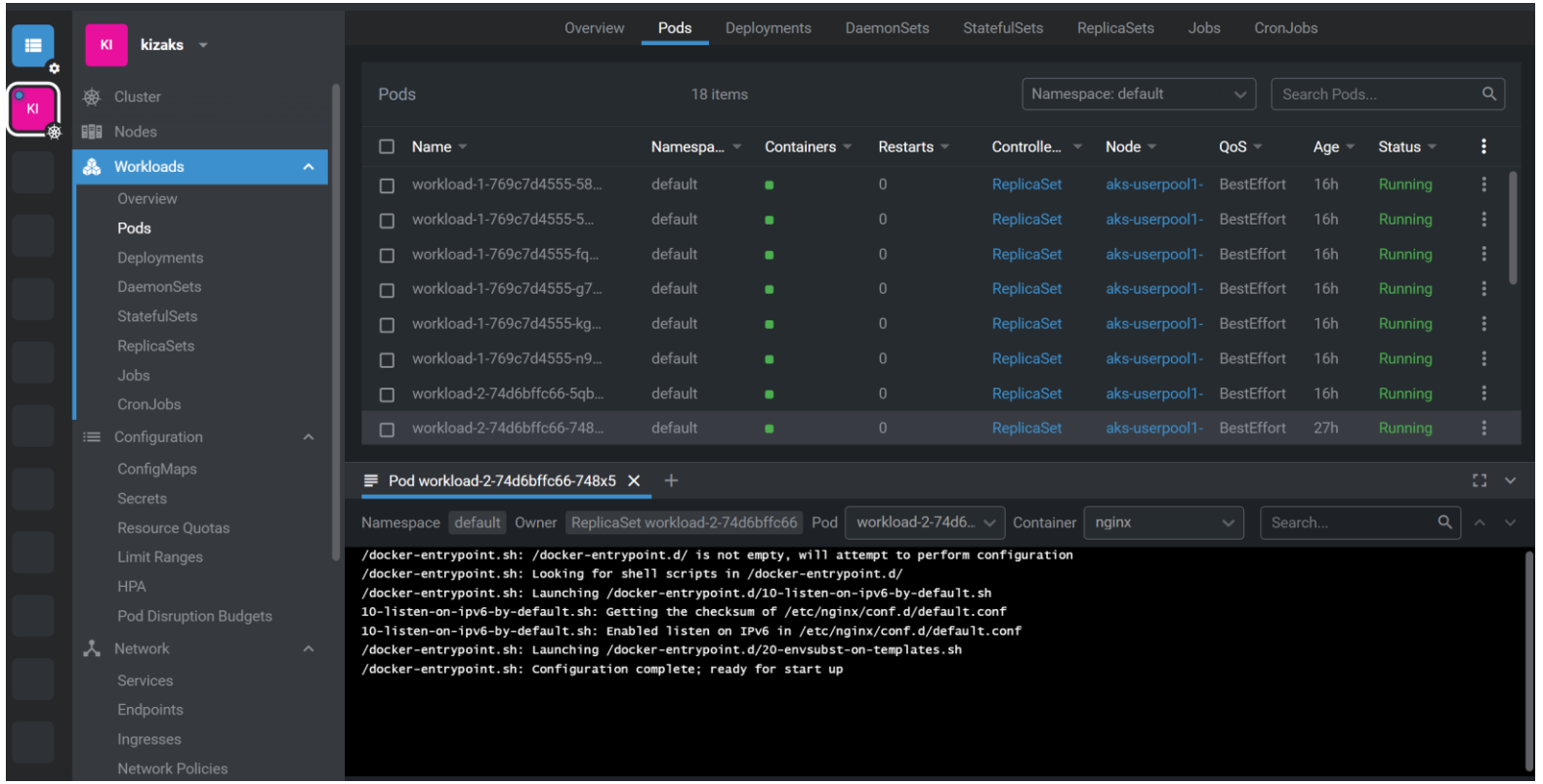
```
helm uninstall demo
```

Helm Demo

Use Helm to manage application releases to an AKS Cluster

PRO TIP: Use Lens to Manage your Cluster

- It's important to be very comfortable using ***kubectl*** to manage your cluster.
- Once you understand the fundamentals of Kubernetes, it's often more efficient to use a free desktop GUI like Lens to observe and manage your cluster.



Lab – Module 3

Intermediate Kubernetes Topics

Microsoft

Thank you