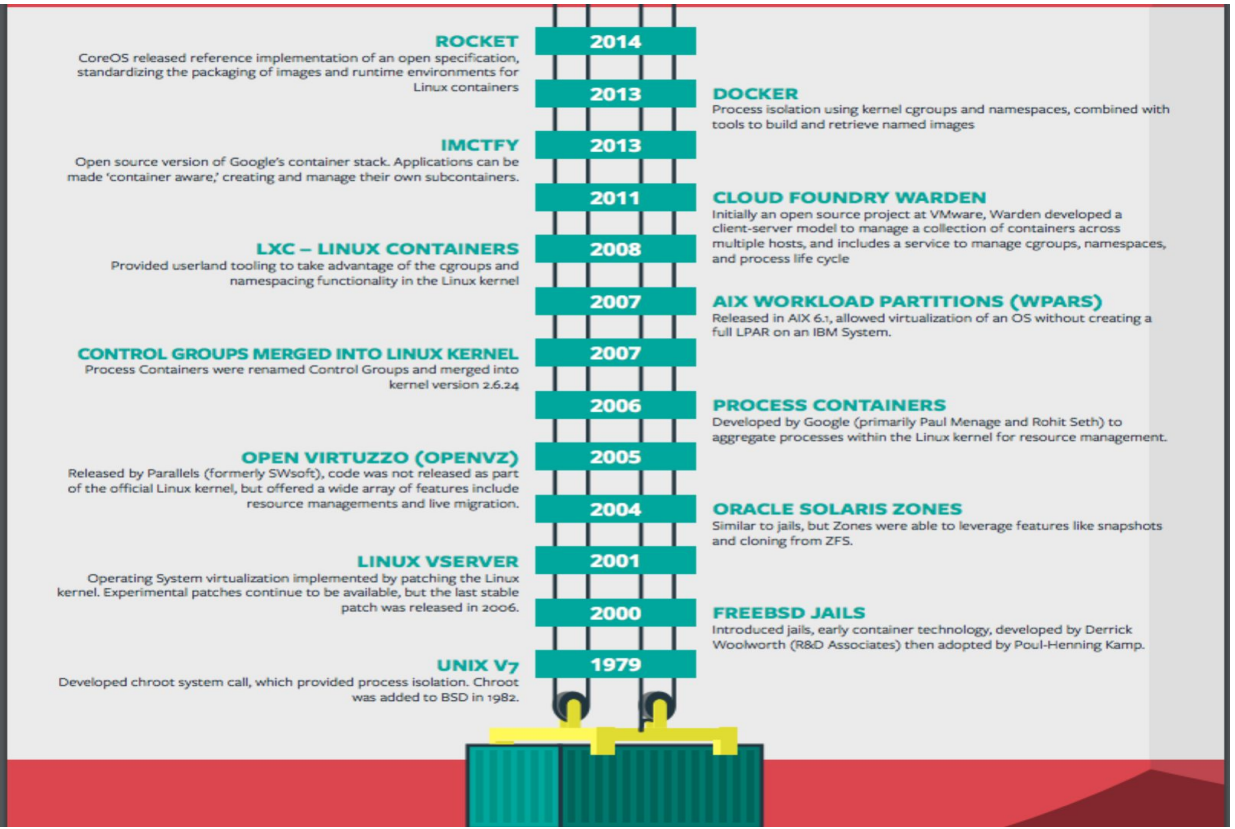
Pivotal

Kubernetes & Pivotal Container Service Overview

Containers

Introduction to Containers

Brief History of Containers



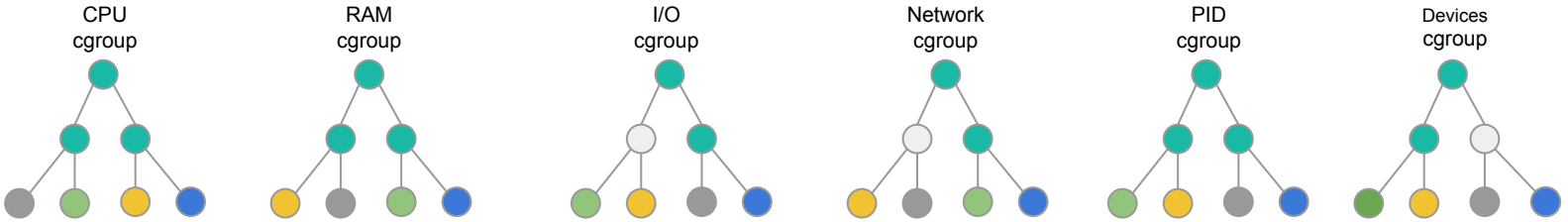
- **2006:** Rohit Seth and Paul Menage introduced the concept of Control groups
- **2011:** Warden was developed by Pieter Noordius and others at Vmware
- **2013:** Docker was developed at DotCloud
- **2014:** Warden rewritten in Go into Garden by Alex Suraci and others.

Open Container Initiative

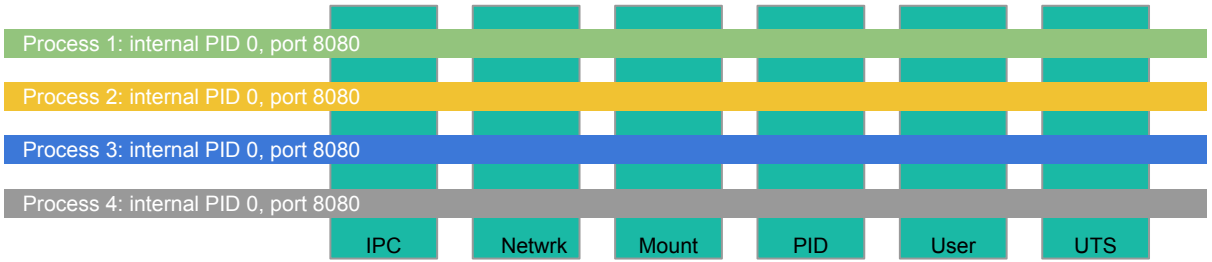
- The OCI is run under the auspices of the Linux Foundation
- It defines specs for container format and runtime (OCF – Open Container Format).
- Reference implementation is called RunC
- Initial specs and reference implementation is provided by Docker
- Drivers:
  - A container not bound to higher level constructs such as a particular client or orchestration stack, and
  - A container not tightly associated with any particular commercial vendor or project, and
  - A container portable across a wide variety of operating systems, hardware, CPU architectures, public clouds, etc.

Containers

Cgroups (control groups): hierarchical controls for CPU, RAM, I/O, network, PID, Devices; control “what a process is able to do”
Each process belongs to a cgroup of each type

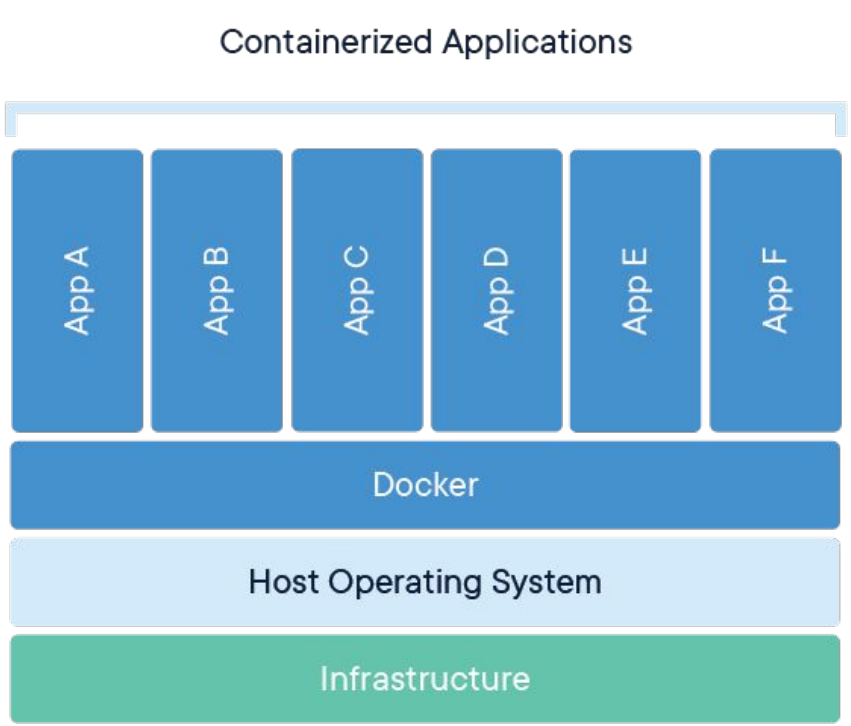


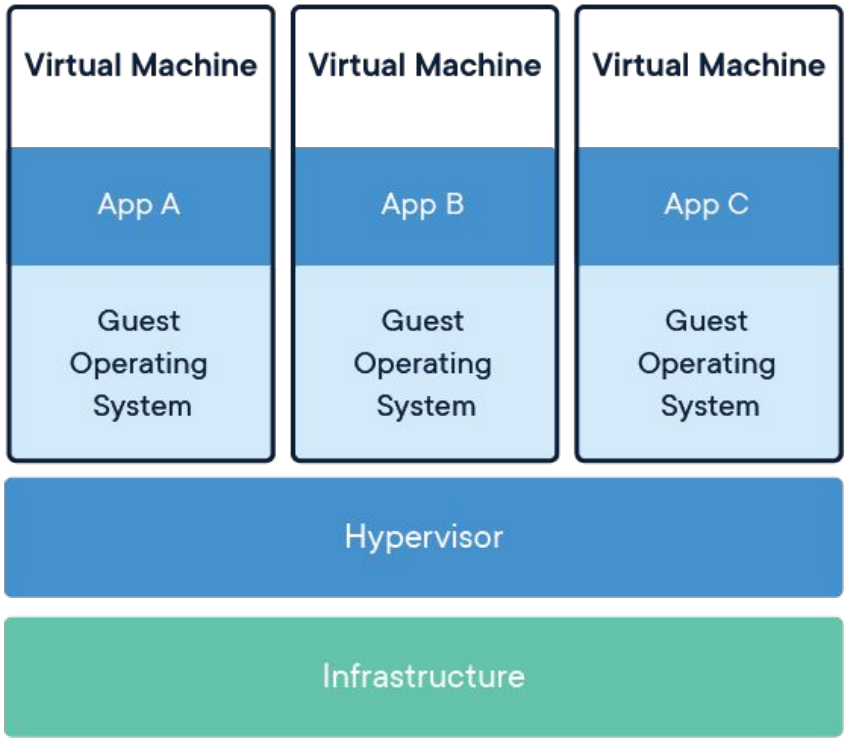
namespaces: control “what a process is able to see” for IPC queues, Network, FS Mounts, PID, User, UTS
Each process is in one namespace of each type. The process’s namespace is destroyed when it exits



Pivotal

Docker


Containerized Applications
App A
App B
App C
App D
App E
App F
Docker
Host Operating System
Infrastructure


Virtual Machine
Virtual Machine
Virtual Machine
App A
App B
App C
Guest Operating System
Guest Operating System
Guest Operating System
Hypervisor
Infrastructure

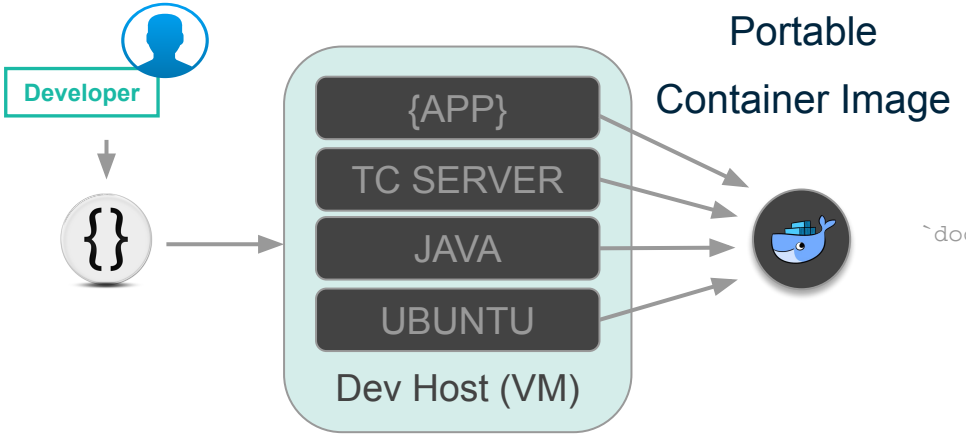
What is a Dockerfile

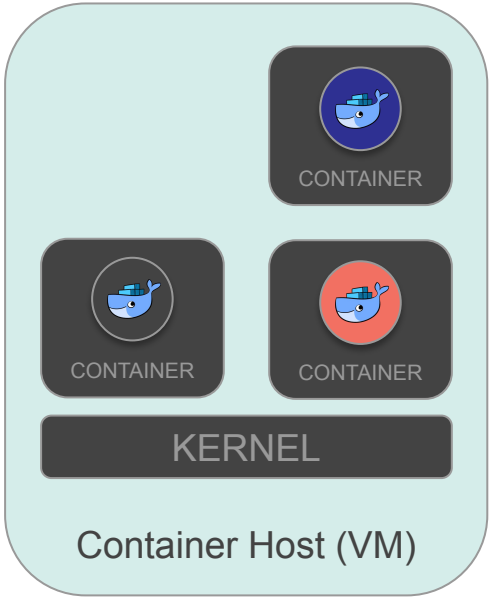
- FROM
- ADD
- RUN
- ENTRYPOINT
- CMD

Dockerfile

```
1  FROM dockerfile/ubuntu
2
3  MAINTAINER Abhinav Ajgaonkar <abhinav316@gmail.com>
4
5  # Install Redis
6  RUN   \
7    apt-get -y -qq install python redis-server
8
9  # Install Node
10 RUN   \
11   cd /opt && \
12   wget http://nodejs.org/dist/v0.10.28/node-v0.10.28-linux-x64.tar.gz && \
13   tar -xzf node-v0.10.28-linux-x64.tar.gz && \
14   mv node-v0.10.28-linux-x64 node && \
15   cd /usr/local/bin && \
16   ln -s /opt/node/bin/* . && \
17   rm -f /opt/node-v0.10.28-linux-x64.tar.gz
18
19 # Set the working directory
20 WORKDIR   /src
21
22 CMD ["/bin/bash"]
```

What do Containers Bring?





- **Reliable Packaging**
- **Server/VM Density**
- **Fast Time To Launch**
- **Built for CI/CD**

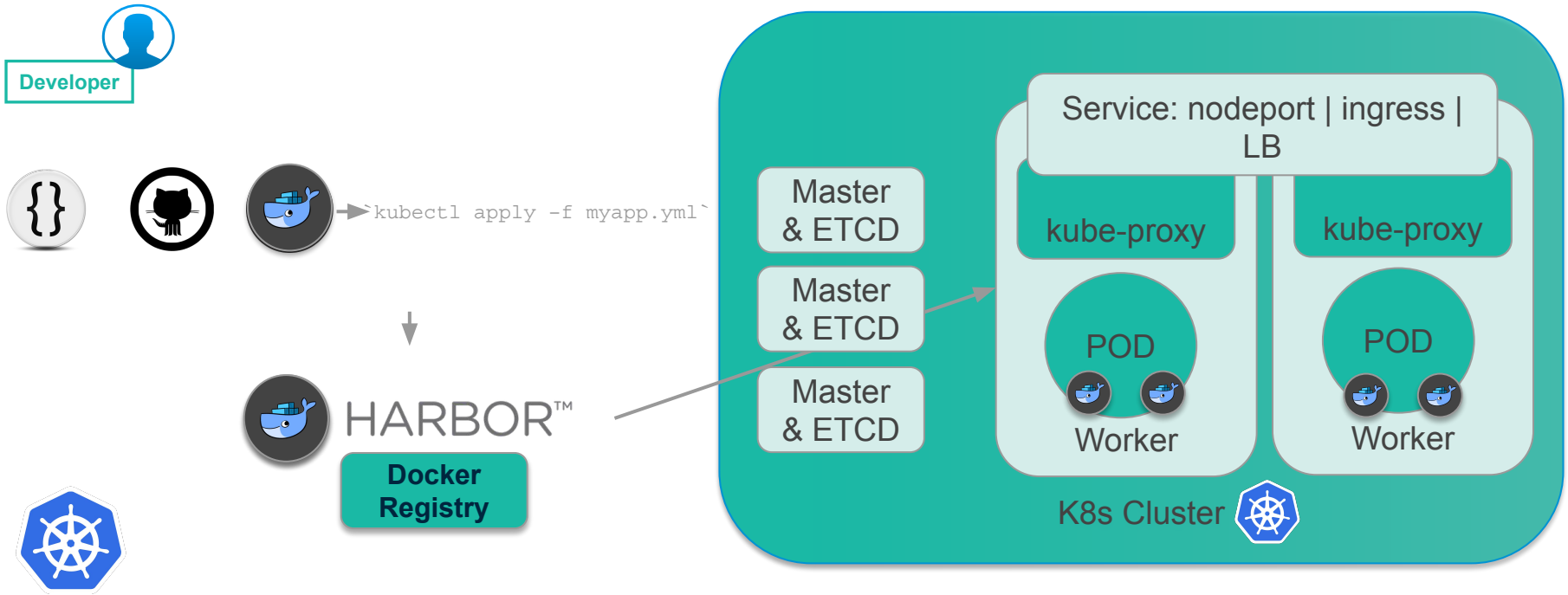
Kubernetes

K8s 101

Pivotal

Kubernetes 101

Containers @ Scale



kubernetes

Container Orchestrator

"Run this containerized app for me. Let me tell you how."

Ideal for packaged apps, apps/services exposing multiple ports and where finer grained control is needed

Containerized workloads. Custom and ISV packaged apps and services delivered as containers

Stateful services. Services using persistent storage such as MongoDB, Cassandra, Spark, Elastic Search, CouchDB

Customization. Specify how your app is deployed and operated to optimize performance and reliability

Additional References: KubeAcademy

Basics Beginner

Getting Started

The Getting Started course is designed to orient students with the Cloud Native ecosystem. Learn why Cloud Native and Kubernetes is becoming an important must-know technology today!

4 Lessons • 36:45

Basics Beginner

Containers 101

This course lays the groundwork for your Kubernetes journey. You'll learn foundational knowledge on containers and how they work.

3 Lessons • 25:55

Basics Beginner

Kubernetes 101

This course lays out the case for container orchestration and provides an overview of the concepts underlying Kubernetes, the leading container orchestration platform.

2 Lessons • 14:53

https://kube.academy/

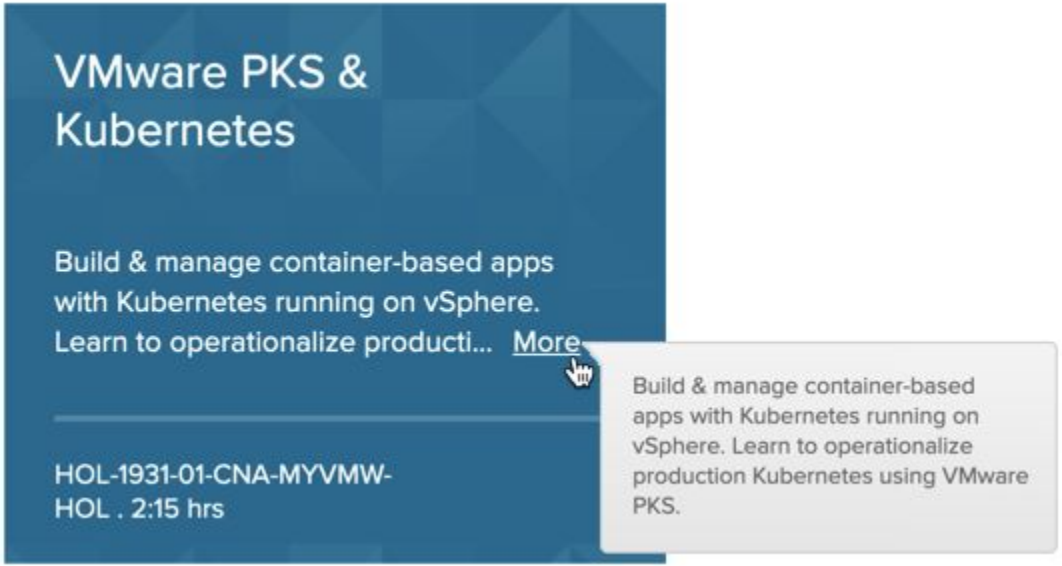
Kubernetes Certification

- Meant mostly for Devs (DevOps)
- 2h exam
- 19 questions
- Passing grade - 66%
- Certification Details

- Meant mostly for Ops / Administrators
- 3h exam
- 24 questions
- Passing grade - 74%
- Certification Details

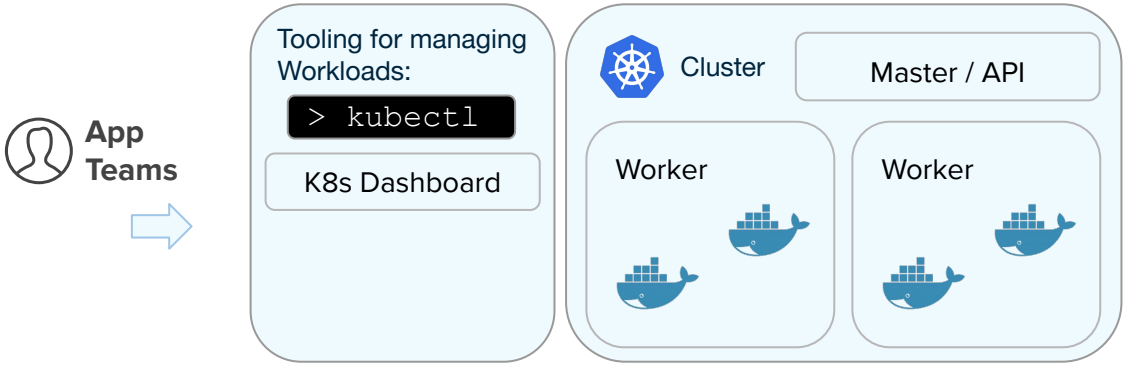
- Udemy CKAD course (often on discount at $10-$15 USD)
  - 96 lectures, 6h videos
- Udemy CKA course (often on discount at $10-$15 USD)
  - 217 lectures, 12.5h videos

PKS Hands-On Lab

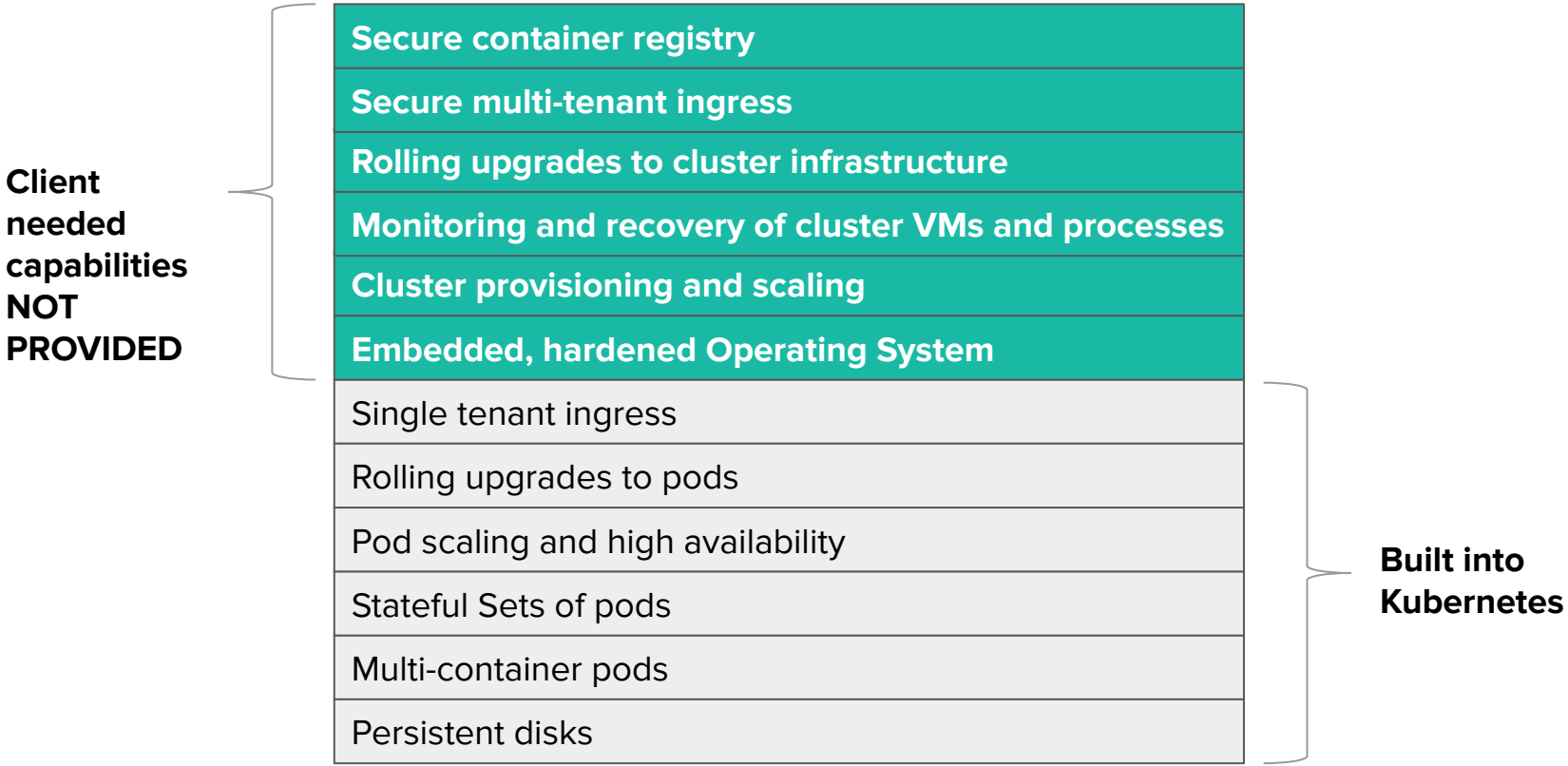


https://my.vmware.com/web/vmware/evalcenter?p=pks-18-hol

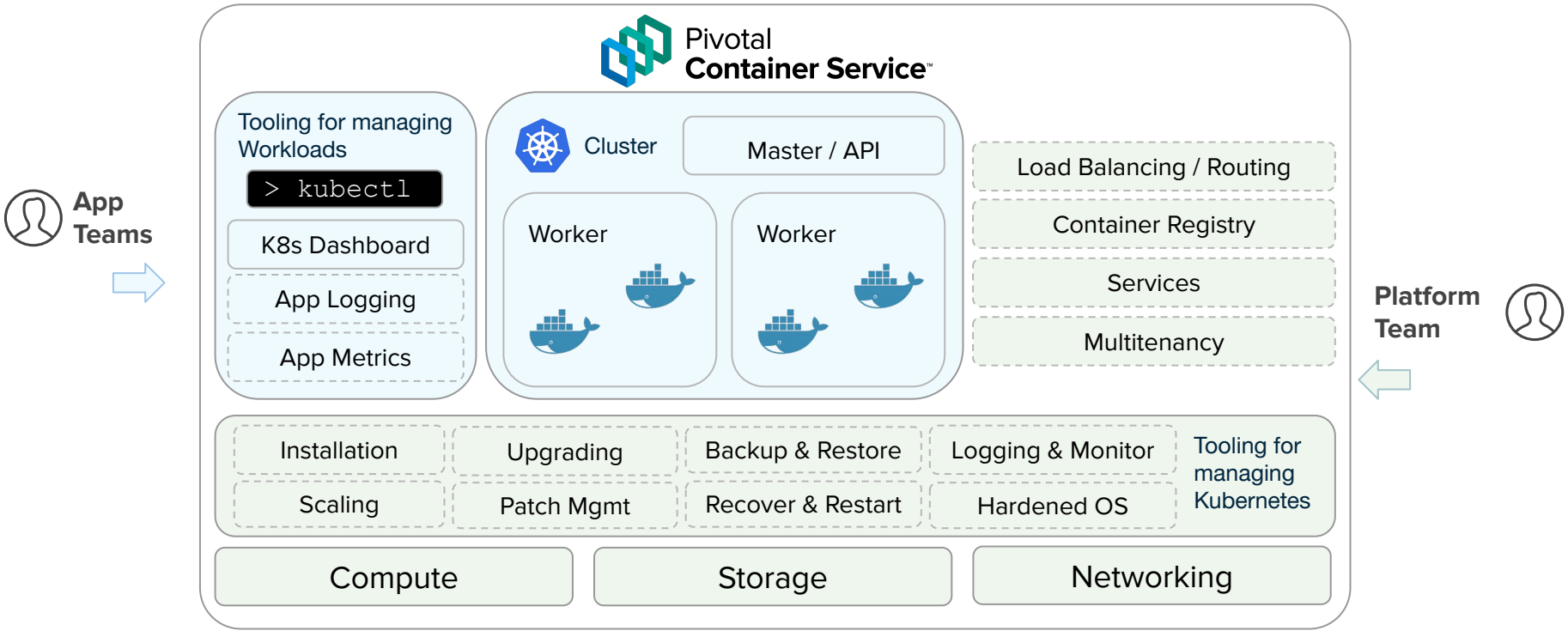
Kubernetes is a Runtime for Containerized Workloads



What Kubernetes provides, what is missing ?



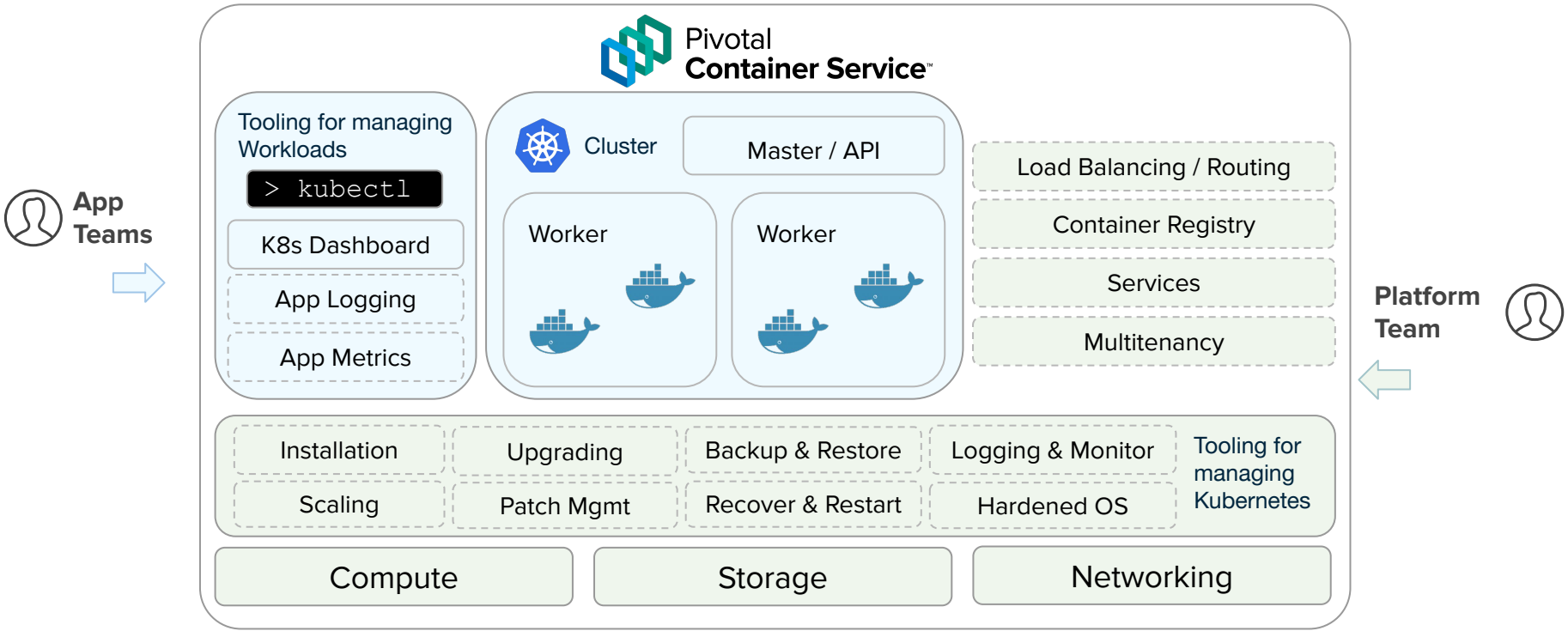
PKS provides what's missing



Differentiators

PKS Secret Sauce

Serving Personas correctly and sustainably



Serving Personas correctly and sustainably

App Teams

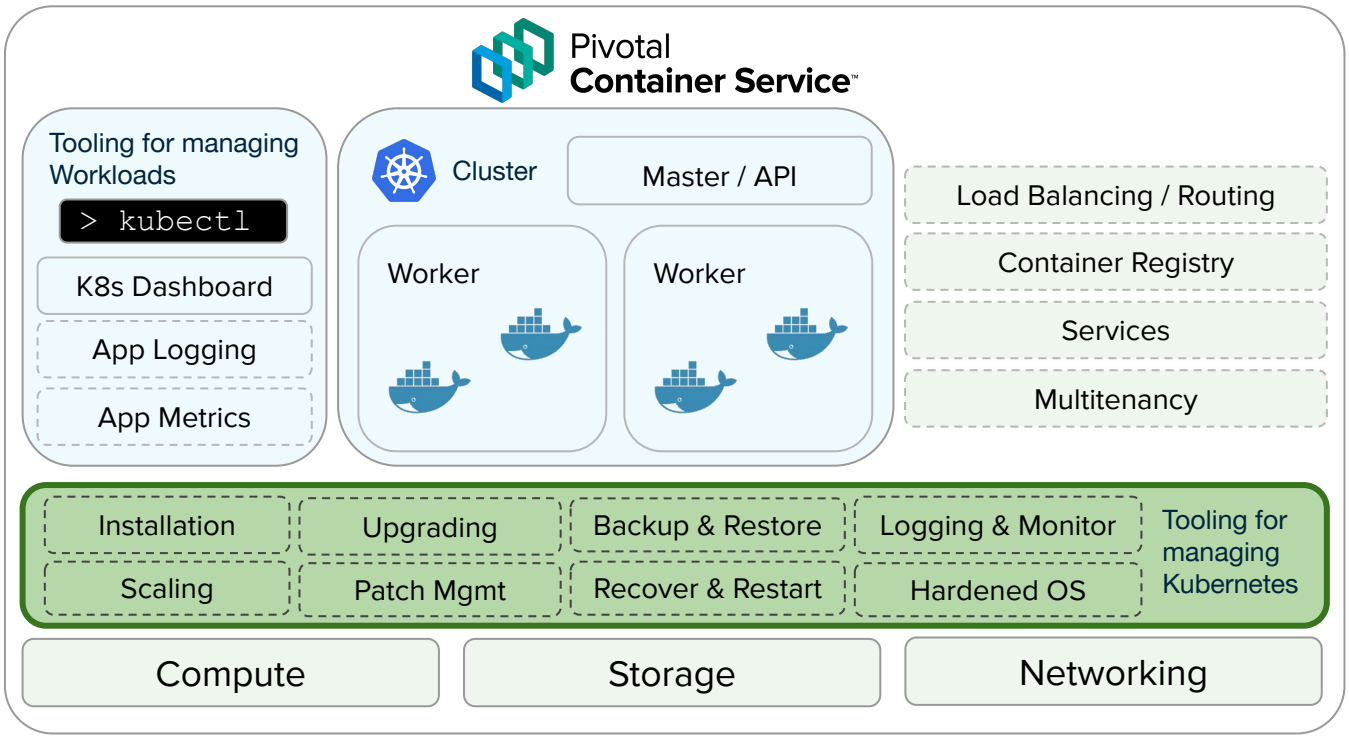
Iteratively building and delivering digital offerings to the consumer, on k8s

Enabling the app teams all while managing Security, Compliance, Resilience, Cost Efficiency

Platform Team

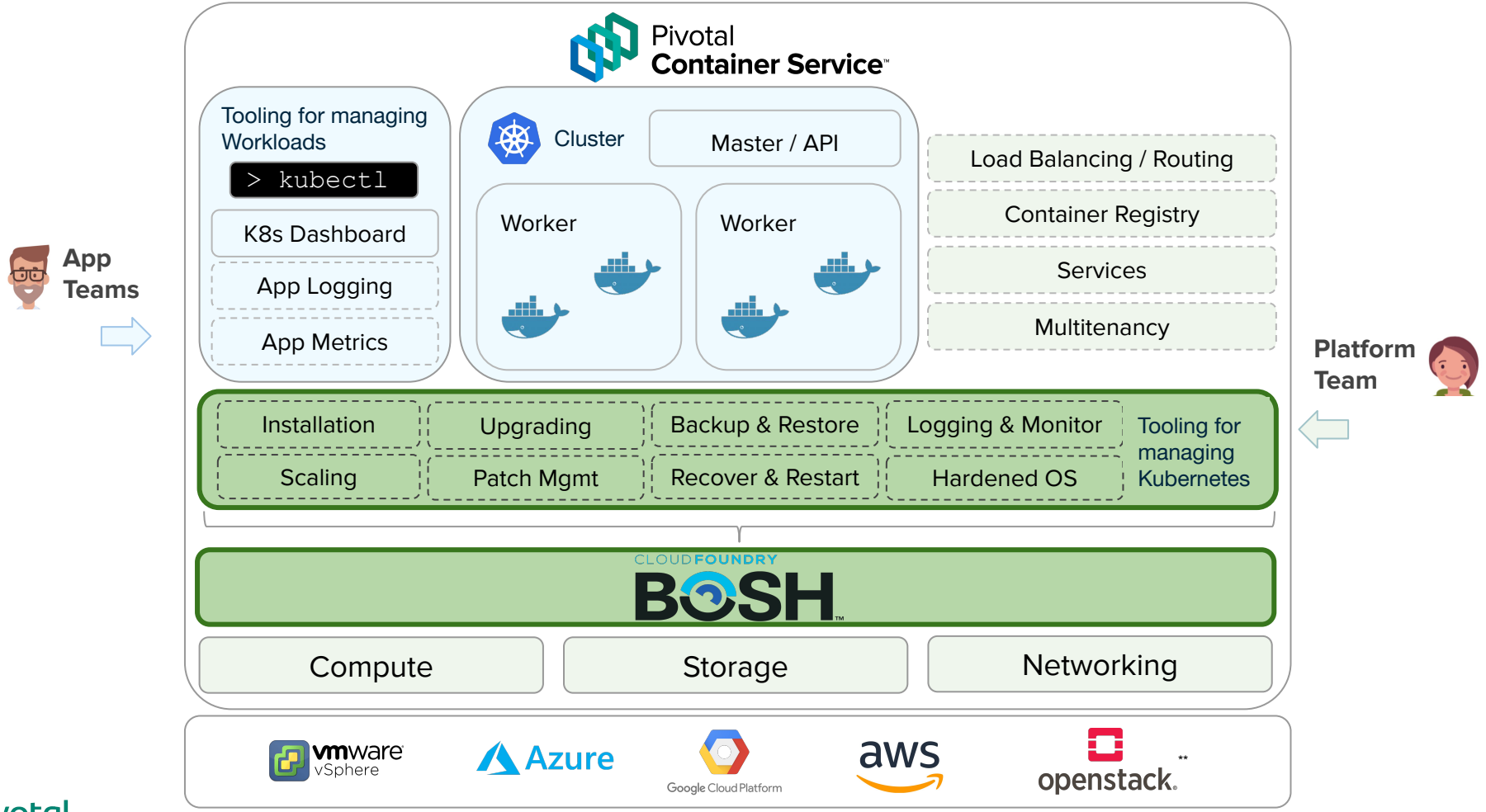
Pivotal

Tooling for managing k8s



App Teams

Platform Team


Pivotal
Container Service
Tooling for managing Workloads
> kubectl
K8s Dashboard
App Logging
App Metrics
Cluster
Master / API
Worker
Worker
Load Balancing / Routing
Container Registry
Services
Multitenancy
App Teams
Platform Team
Installation
Upgrading
Backup & Restore
Logging & Monitor
Scaling
Patch Mgmt
Recover & Restart
Hardened OS
Tooling for managing Kubernetes
CLOUD FOUNDRY
BOSH
Compute
Storage
Networking
vmware vSphere
Azure
Google Cloud Platform
aws
openstack

CVE-2018-1002105: proxy request handling in kube-apiserver can leave vulnerable TCP connections #71411

Closed liggitt opened this issue 11 days ago · 47 comments

liggitt commented 11 days ago • edited Member

CVSS:3.0/AV:N/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H (9.8, critical)

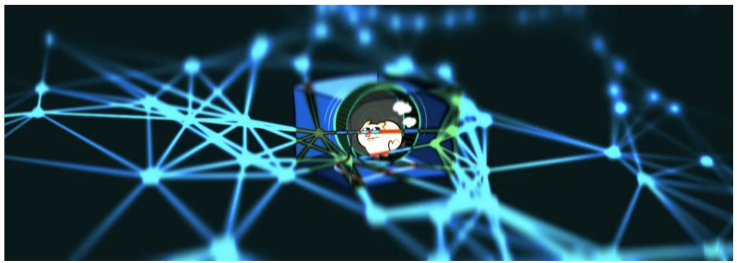
With a specially crafted request, users that are authorized to establish a connection through the Kubernetes API server to a backend server can then send arbitrary requests over the same connection directly to that backend, authenticated with the Kubernetes API server's TLS credentials used to establish the backend connection.

Thanks to Darren Shepherd for reporting this problem.

- VMware/Pivotal engineers added the fix into the latest version of PKS. From there, we built and tested the image.
- The image is ready to ship! It was published on PivNet
- For PKS customers with automated upgrade pipelines, patch is automatically applied to their PKS instances
- The world at large learns about the CVE. PKS customers have been patched for a few days at this point!

RunC Vulnerability Gives Attackers Root Access on Docker, Kubernetes Hosts

By Sergiu Gatlan February 11, 2019 02:10 PM 0



A container breakout security flaw found in the runc container runtime allows malicious containers (with minimal user interaction) to overwrite the host runc binary and gain root-level code execution on the host machine.

Matt Cowger
@mcowger

Following

Sweet. One of my customers upgraded their 7 foundations and over 2 dozen #k8s clusters to @PivotalPKS 1.3.2 today (to patch the runC CVE). In 12 hours. Hands off. No downtime with @concourseci. Last one is finishing tonight while they sleep b/c they have PDBs that slow it.

4:22 PM - 15 Feb 2019

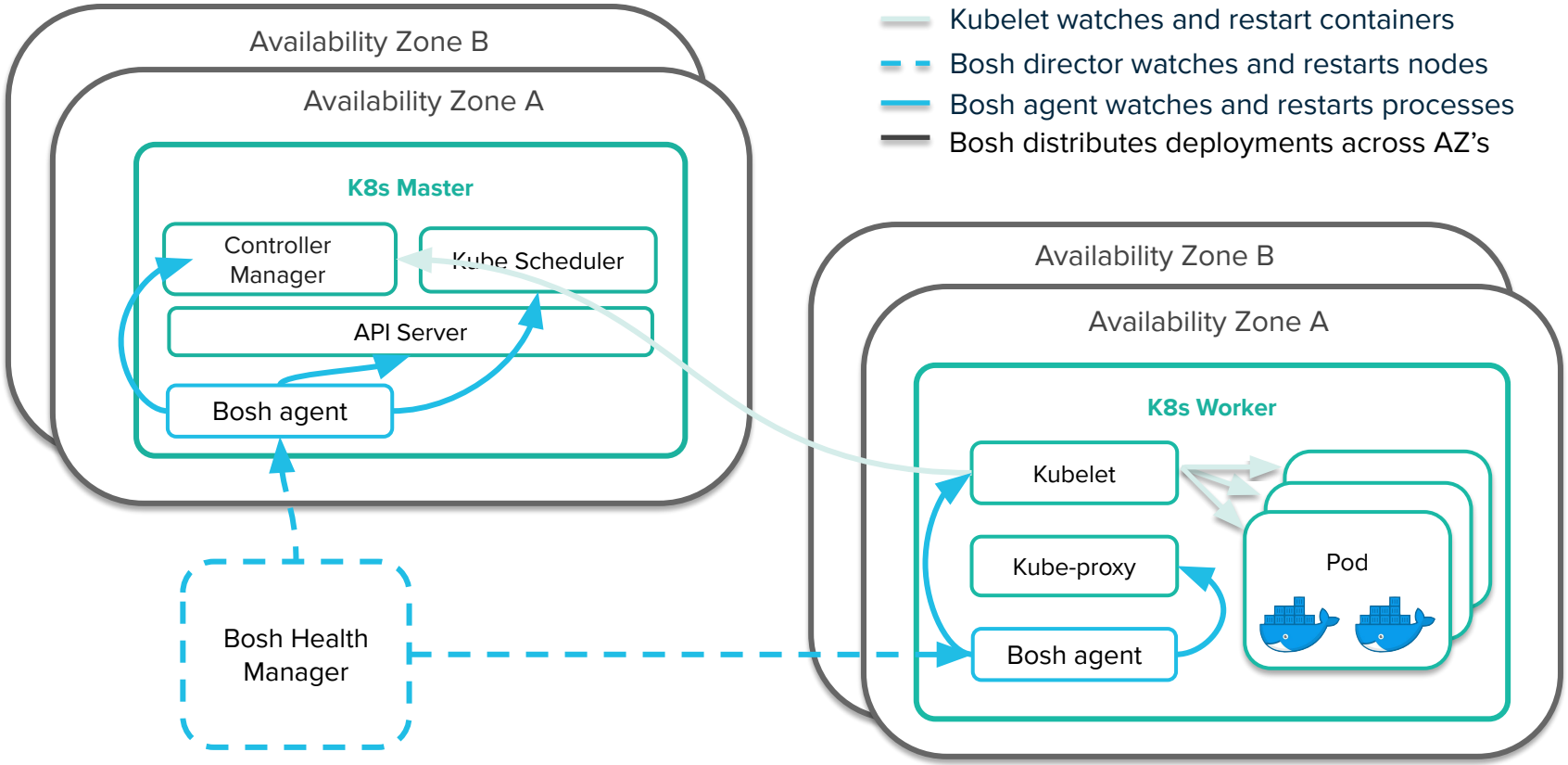
https://content.pivotal.io/pivotal-blog/happy-monday-how-to-fix-a-kubernetes-cve-before-your-boss-and-the-rest-of-the-world-reads-about-it

Pivotal

Kubernetes managed by BOSH

- Zero-Downtime Patching & Upgrade of K8s
- Hardened OS & Zero Downtime Patching of OS for All K8s VMs
- Out-of-box Health Monitoring and Auto-healing for K8s VMs
- Backup & Restore for K8s Control Plane
- Consistent Operating Model Across Public and Private Clouds

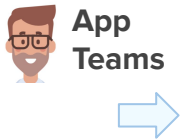
PKS Health Management




PKS does for your Kubernetes
what
Kubernetes does for your apps

Pivotal

Multitenancy



App Teams

Pivotal Container Service™

Tooling for managing Workloads

```
> kubectl
```

K8s Dashboard

App Logging

App Metrics

Cluster

Master / API

Worker

Worker

Load Balancing / Routing

Container Registry

Services

Multitenancy

Platform Team

CLOUD FOUNDRY BOSH™

Installation | Upgrading | Backup & Restore
Logging & Monitor | Scaling | Patch Mgmt
Recover & Restart | Hardened OS

Tooling for managing Kubernetes

Compute

Storage

Networking

vmware vSphere

Azure

Google Cloud Platform

aws

openstack**

Pivotal

Multi-tenancy

Multi-tenant clusters

- Leverage Kubernetes namespaces

Limitations with Kubernetes alone

- Noisy neighbors (workloads can affect other tenants)
- ~~Share the same network~~
- Share DNS
- Shared Configuration
- ...

We add

- Network microsegmentation with NSX-T
  - Eliminating “Share the same network”

Multi (Single-tenant) clusters

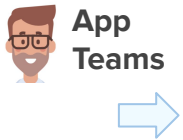
It is having an API for creation and management that enables this!!!

- Every tenant gets their own cluster

Addresses limitations

- Single tenant worker VMs (depend on the hypervisor to ensure host is properly shared)
- Every cluster has own network segment
- Every cluster has own DNS
- Every cluster has own configuration
- ...

Multitenancy



App Teams

Pivotal Container Service™

Tooling for managing Workloads

```
> kubectl
```

K8s Dashboard

App Logging

App Metrics

Cluster

Master / API

Worker

Worker

Load Balancing / Routing

Container Registry

Services

PKS Control Plane

```
> pks
```

Multitenancy | RBAC

Platform Team

CLOUD FOUNDRY BOSH™

Installation | Upgrading | Backup & Restore
Logging & Monitor | Scaling | Patch Mgmt
Recover & Restart | Hardened OS

Tooling for managing Kubernetes

Compute

Storage

Networking

vmware vSphere

Azure

Google Cloud Platform

aws

openstack®

Pivotal

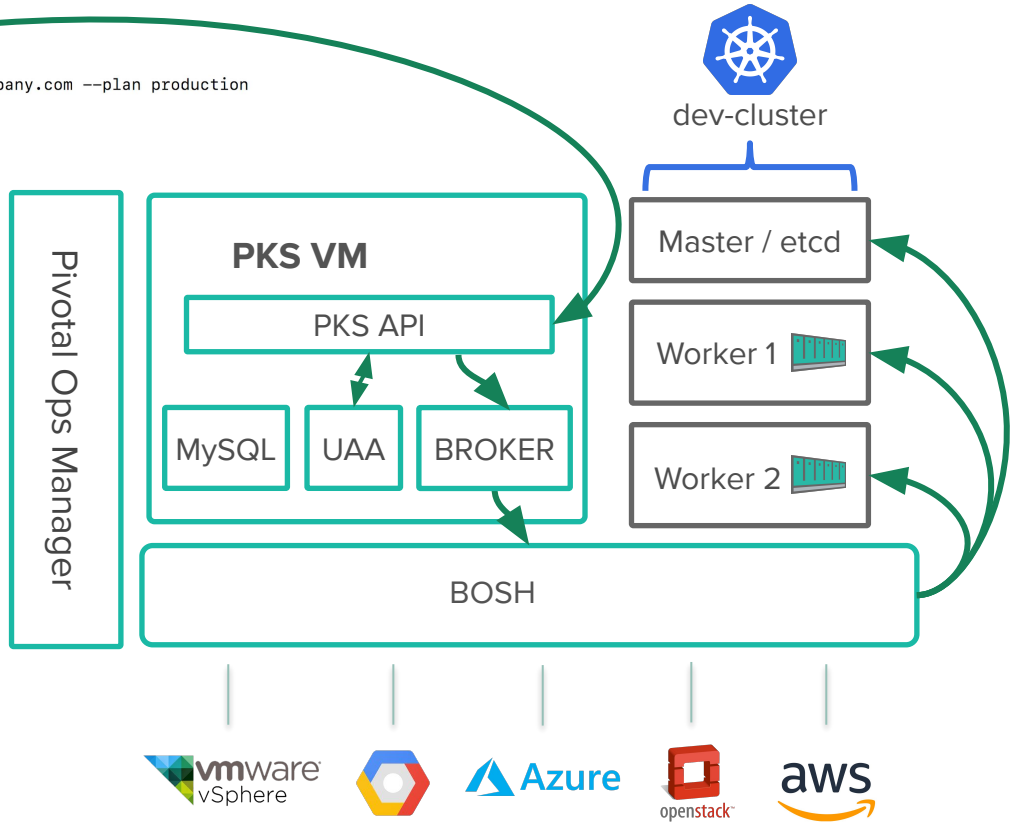
PKS Control Plane to manage multiple k8s clusters

- Self-service, on-demand provisioning of clusters
- Pre-defined T-shirt size clusters
- Scale clusters up and down
- REST API makes Multi-Cluster Easy
- AuthN and RBAC for API(s) access

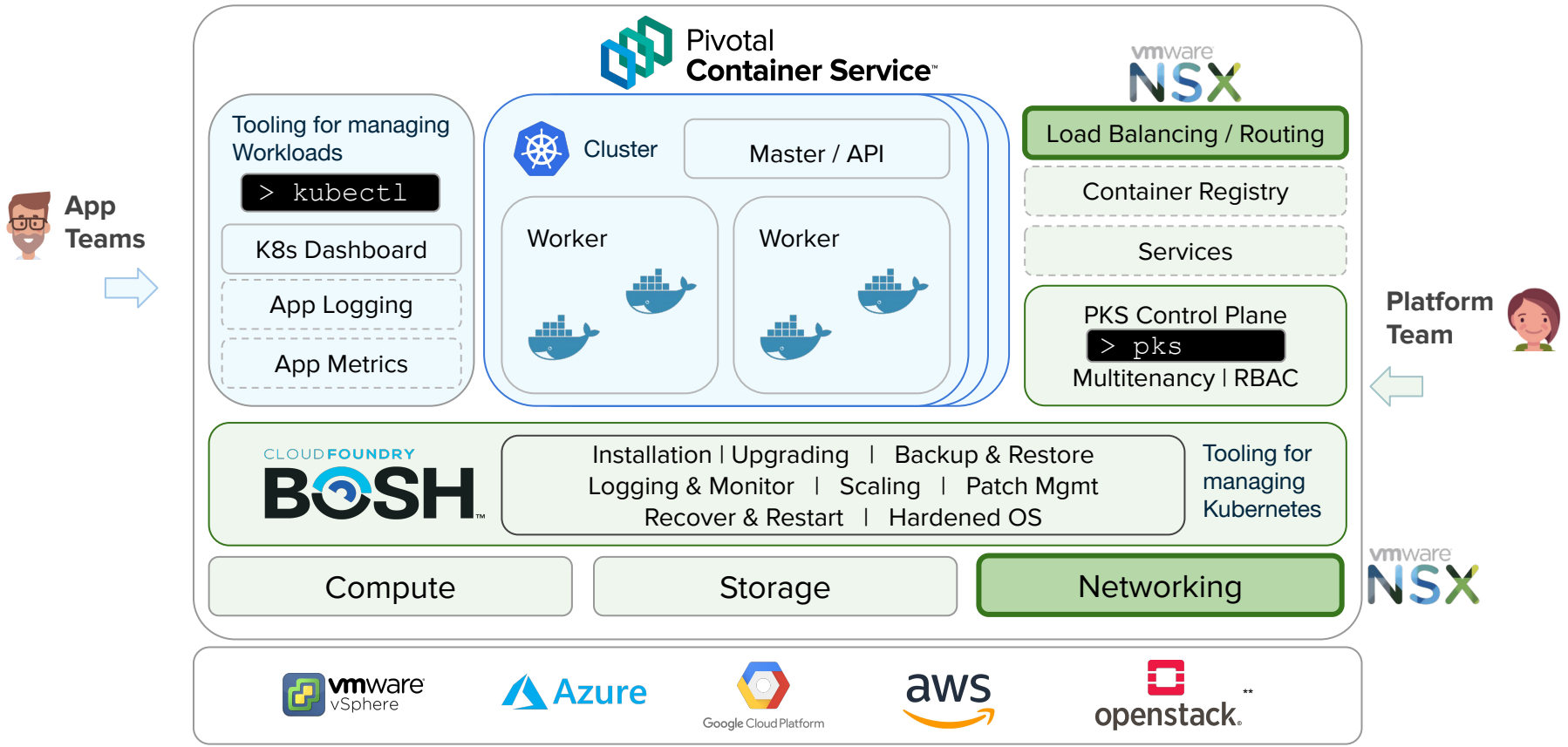
Deploying a Kubernetes Cluster via PKS

```
○ → pks create-cluster dev-cluster --external-hostname dev-cluster.k8s.company.com --plan production

Name:                     dev-cluster
Plan Name:
UUID:                     e28d1e85-d136-46f6-b0d6-ec8a2f79b8f6
Last Action:              CREATE
Last Action State:        in progress
Last Action Description:  Creating cluster
Kubernetes Master Host:   dev-cluster.k8s.company.com
Kubernetes Master Port:   8443
Worker Instances:         set via plan default
```



Networking, Load Balancing / Routing



Software Defined Networking for Kubernetes with NSX-T

- Microsegmentation with Network Security policies
- Automated IP allocation and load balancer provisioning
- Monitoring & troubleshooting with familiar VMware tooling
- Unique logical switch per K8s namespace

Pivotal

Pivotal Container Service

Supported Network Alternatives

flannel (+ PROJECT CALICO)

Open Source — Open source projects. Supported by the community and specific vendors.

Any Infrastructure — Will run on any infrastructure, public or private cloud.

Simple overlay network — Flannel provides a simple overlay network.

Requires Calico for policy management — Flannel is only concerned about networking. Network policy management is done by integrating with Calico.

Single tenancy model Flannel uses a single network for each K8s cluster. Policies can be enforced by using Calico.

Container-only security model security policies using Calico are for the K8s cluster only.

Must setup separately, for each cluster — Flannel and Calico need to be installed for each cluster.

vmware NSX-T

VMware product (included in PKS) — Supported by VMware, entitlement / license included in PKS.

VSphere and VMC — NSX-T is compatible with VSphere or VMC (VSphere on AWS). GCP and Azure support are roadmap items.

Nested network virtualization — Full network virtualization and micro-segmentation.

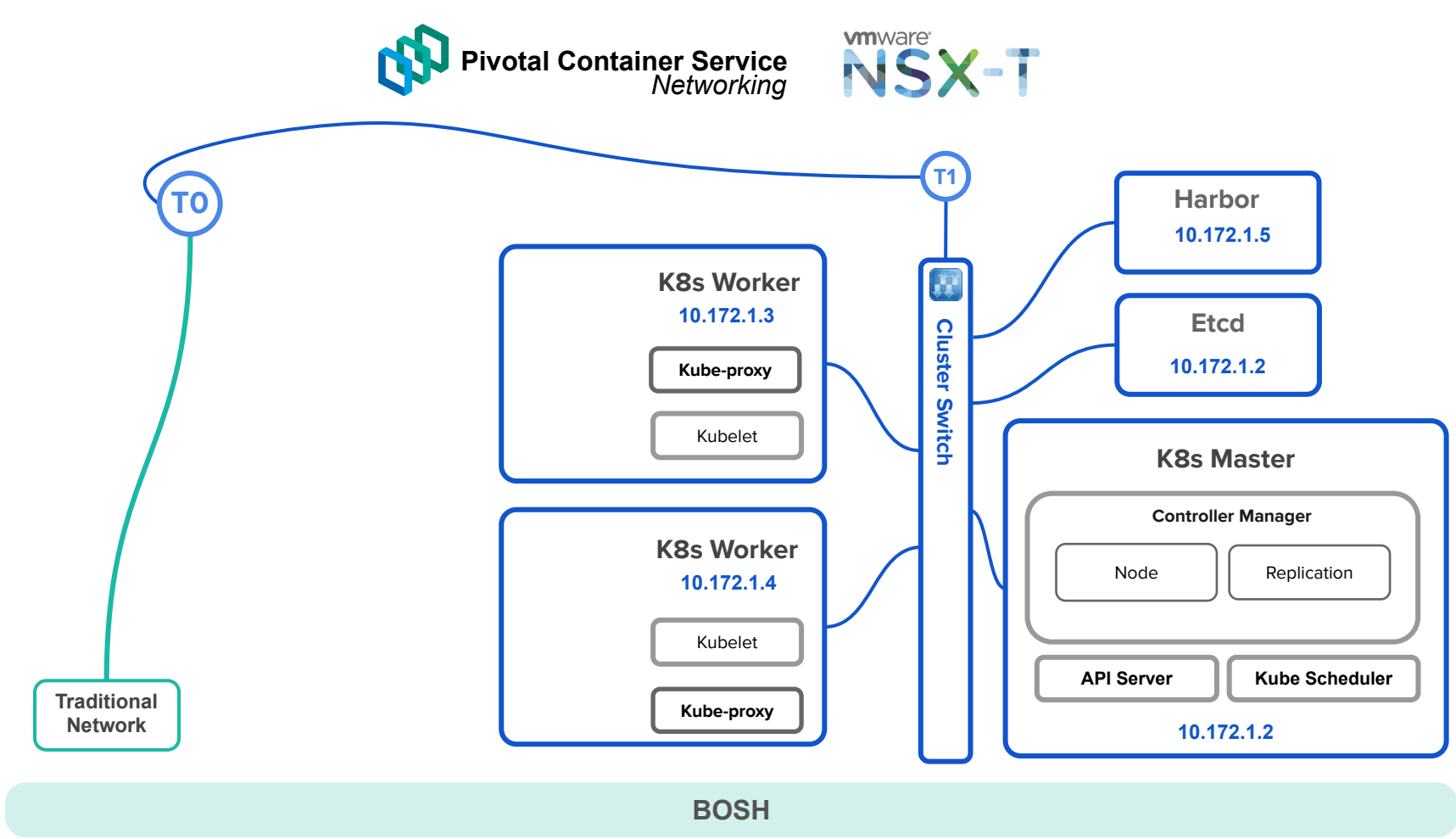
Built-in policy management — NSX-T plugs into Kubernetes through the CNI and enforces configured policies.

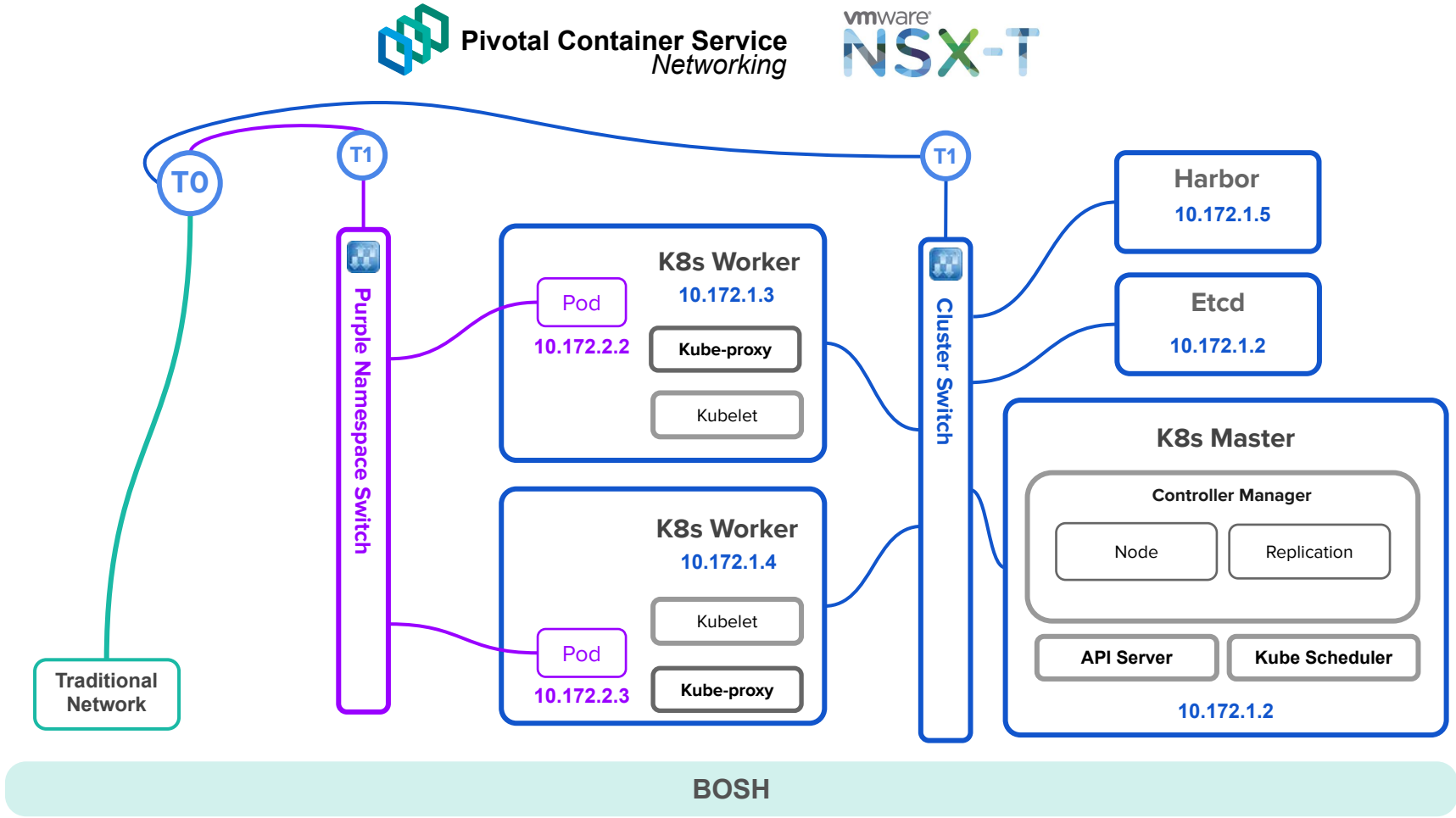
Built-in multi-tenancy NSX-T deploys one logical switch per k8s namespace. So tenants can be isolated by using different namespace constructs. Routers are deployed automatically per K8s Namespace.

Load Balancer support NSX-T supports the deployment of dynamic load balancers (LB services)

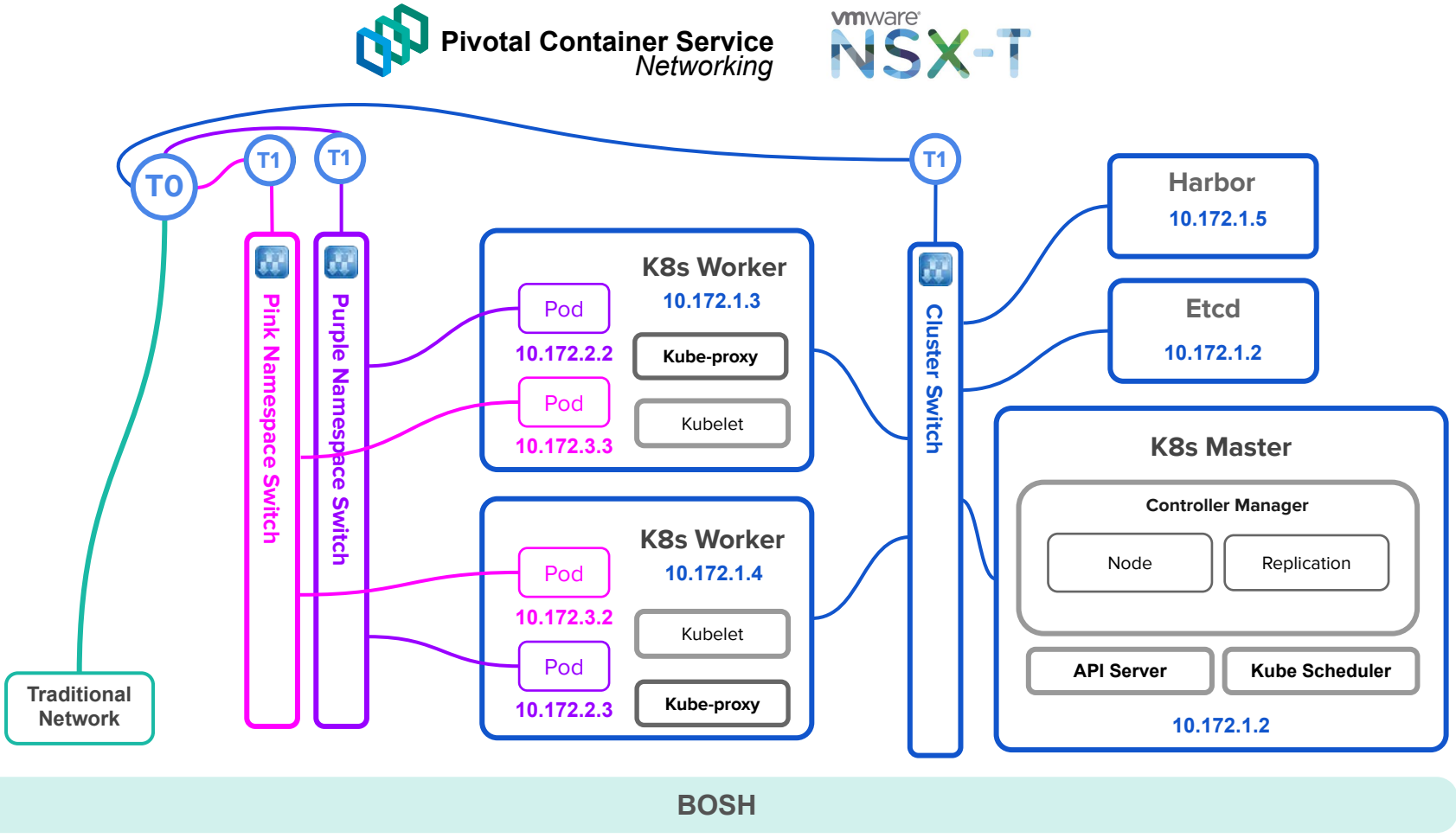
Comprehensive VM + Container security model Policies applied to NSX-T encompasses both containers and VMs running them

NSX-T setup — The NSX-T basic install is done once in the target vSphere cluster.


Pivotal Container Service
Networking
vmware
NSX-T
T0
T1
Traditional Network
K8s Worker
10.172.1.3
Kube-proxy
Kubelet
K8s Worker
10.172.1.4
Kubelet
Kube-proxy
Cluster Switch
Harbor
10.172.1.5
Etcd
10.172.1.2
K8s Master
Controller Manager
Node
Replication
API Server
Kube Scheduler
10.172.1.2
BOSH

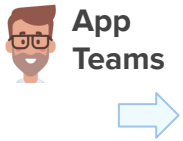

Pivotal Container Service
Networking
vmware
NSX-T
T0
T1
T1
Purple Namespace Switch
Pod
10.172.2.2
K8s Worker
10.172.1.3
Kube-proxy
Kubelet
K8s Worker
10.172.1.4
Kubelet
Pod
10.172.2.3
Kube-proxy
Cluster Switch
Harbor
10.172.1.5
Etcd
10.172.1.2
K8s Master
Controller Manager
Node
Replication
API Server
Kube Scheduler
10.172.1.2
Traditional Network
BOSH

Pivotal


Pivotal Container Service
Networking
vmware
NSX-T
T0
T1
T1
T1
Pink Namespace Switch
Purple Namespace Switch
Cluster Switch
Traditional Network
K8s Worker
10.172.1.3
Pod
10.172.2.2
Pod
10.172.3.3
Kube-proxy
Kubelet
K8s Worker
10.172.1.4
Pod
10.172.3.2
Pod
10.172.2.3
Kubelet
Kube-proxy
Harbor
10.172.1.5
Etcd
10.172.1.2
K8s Master
Controller Manager
Node
Replication
API Server
Kube Scheduler
10.172.1.2
BOSH

Pivotal

Container Registry



App Teams

Pivotal Container Service™

Tooling for managing Workloads

`> kubectl`

K8s Dashboard

App Logging

App Metrics

Cluster

Master / API

Worker

Worker

vmware NSX LB / Routing

Container Registry

HARBOR™

Services

PKS Control Plane

`> pks`

Multitenancy | RBAC

Platform Team

CLOUD FOUNDRY BOSH™

Installation | Upgrading | Backup & Restore
Logging & Monitor | Scaling | Patch Mgmt
Recover & Restart | Hardened OS

Tooling for managing Kubernetes

Compute

Storage

vmware NSX Networking

vmware vSphere

Azure

Google Cloud Platform

aws

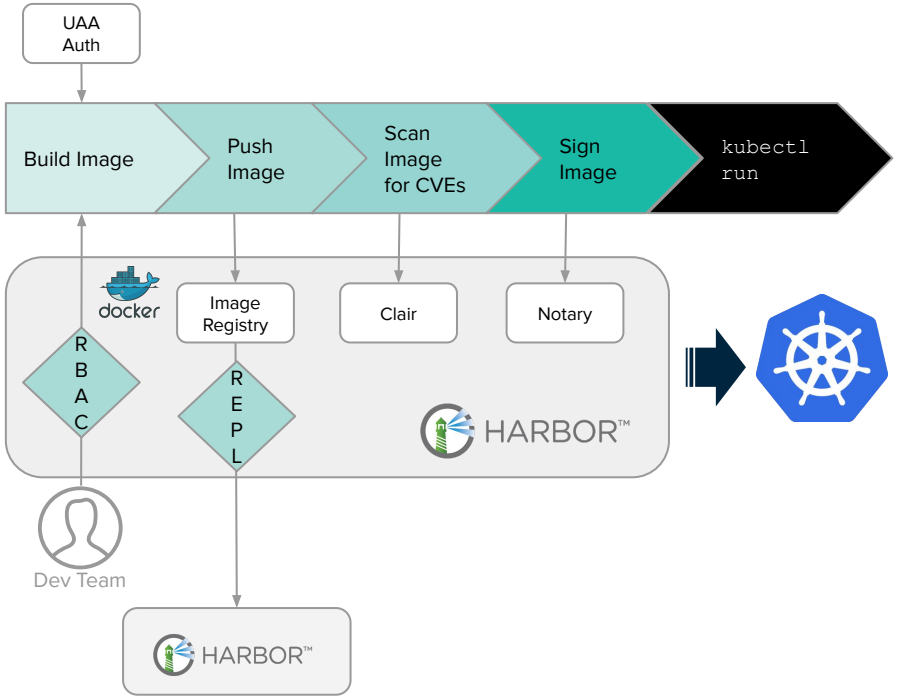
openstack®

Pivotal

Harbor Private Registry

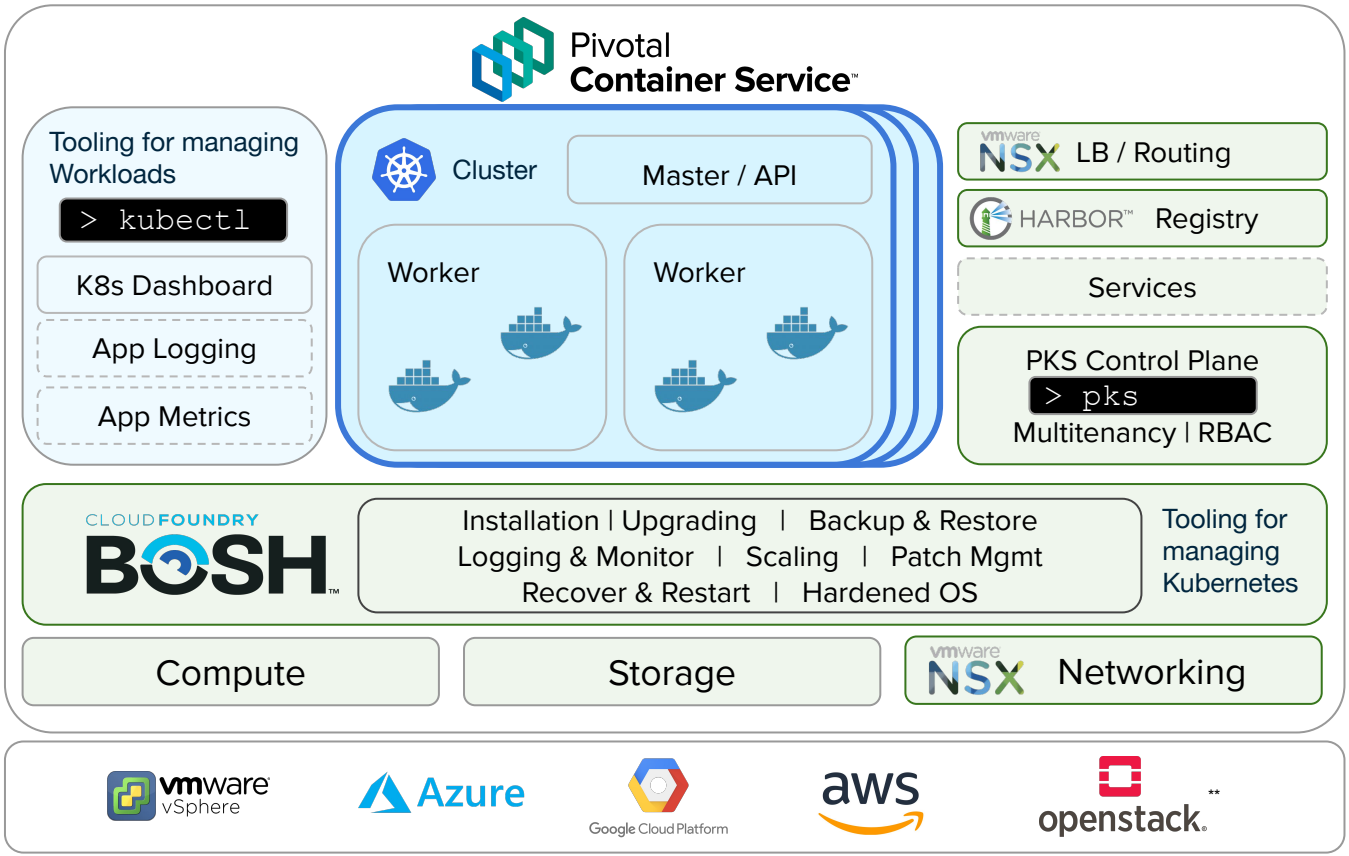
HARBOR™

An enterprise-class registry server for Docker images



Pivotal

Latest upstream stable k8s version



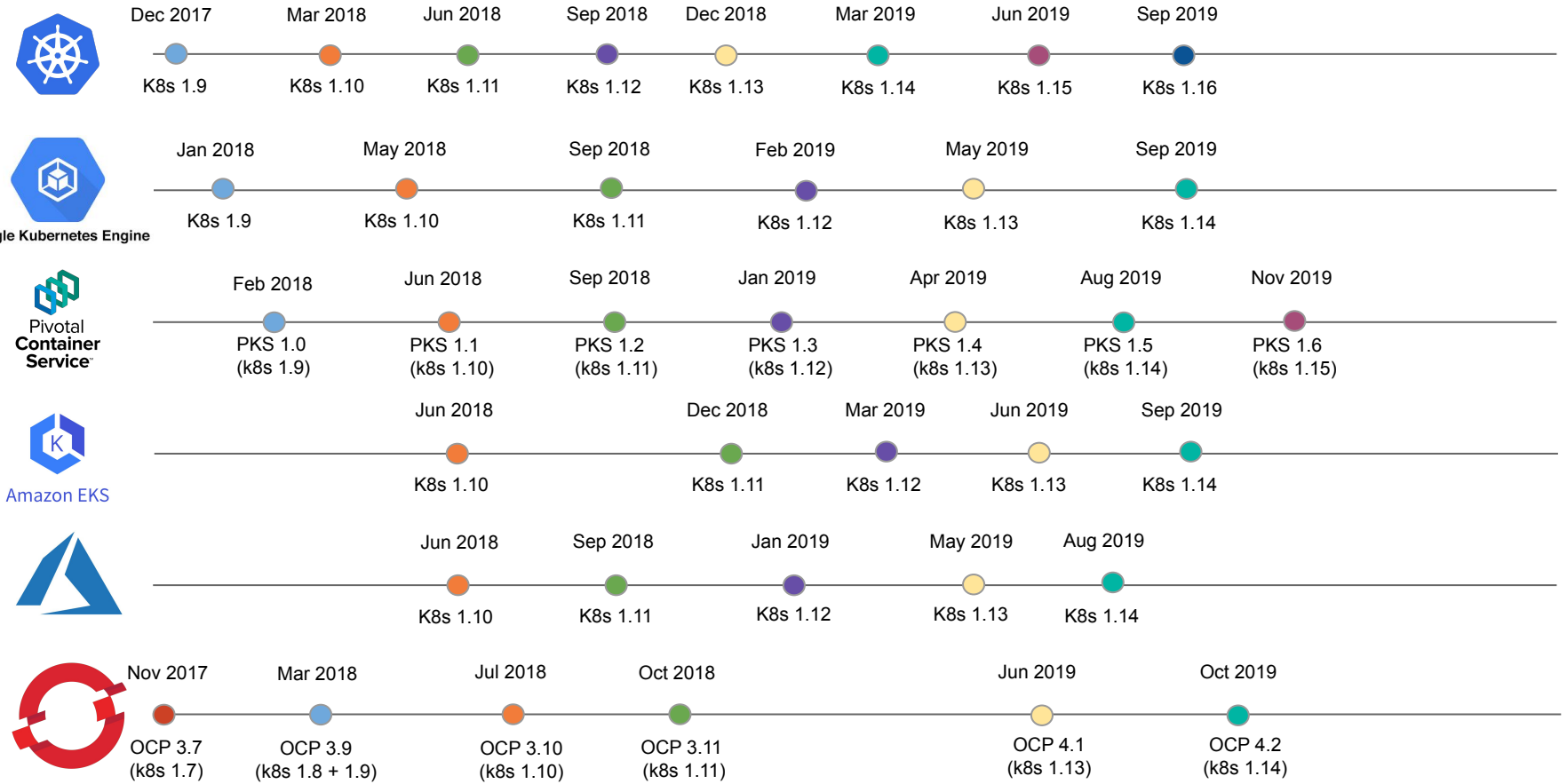
App Teams

Platform Team

Pivotal

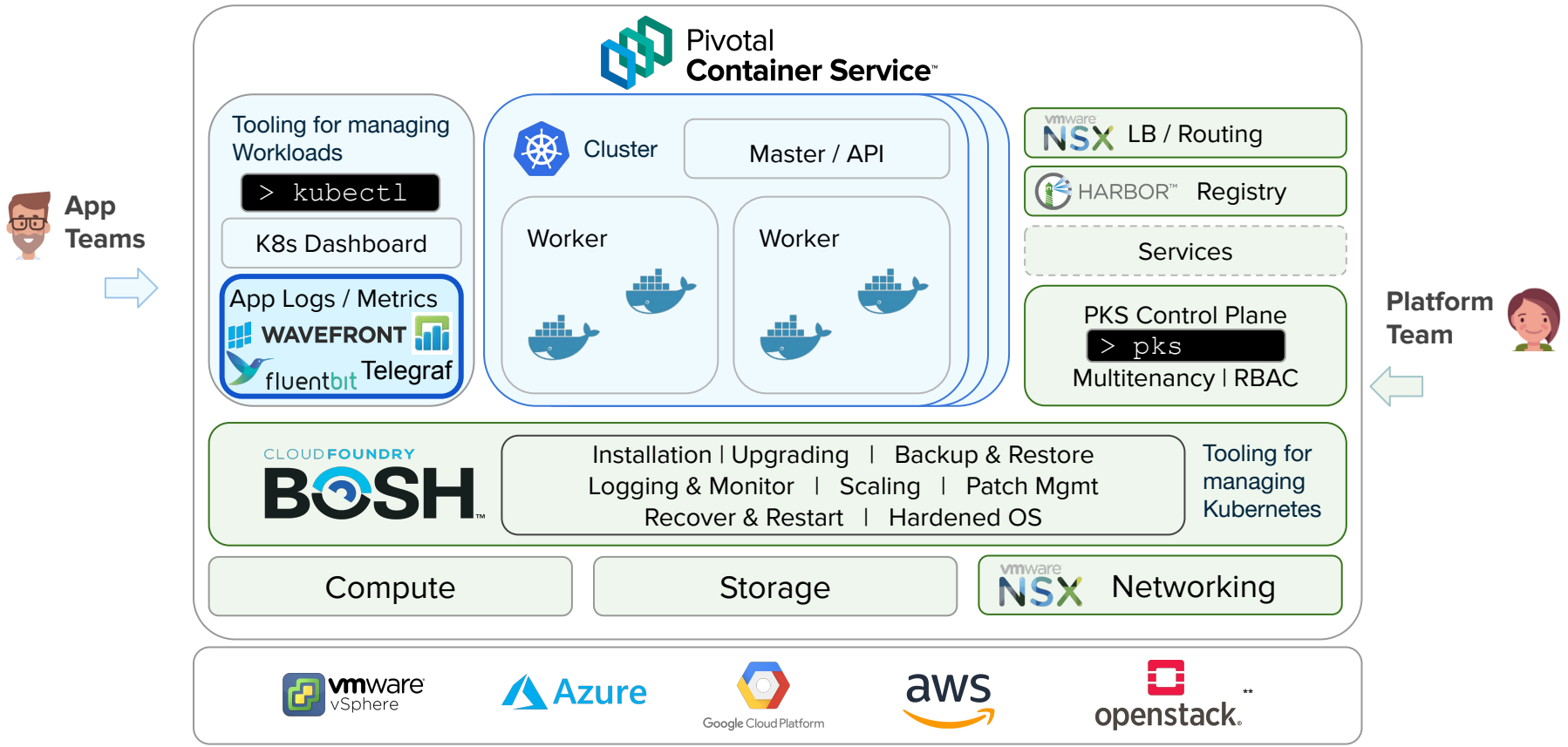
Latest upstream stable k8s version

Updated 12/03/2019



** Only Generally Available versions considered

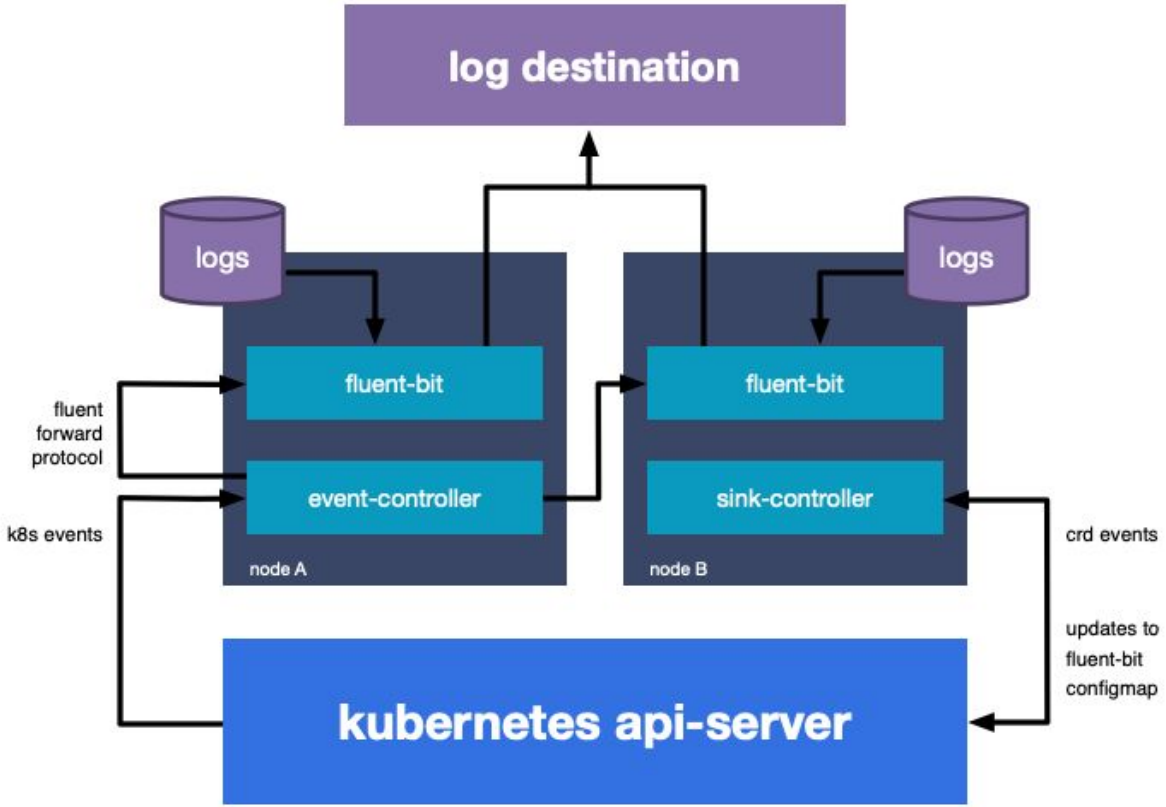
App Logging and Metrics



Dev Productivity: Log Sinks

Application Logging by Cluster or Namespace

- Syslog endpoints
- Webhook endpoints



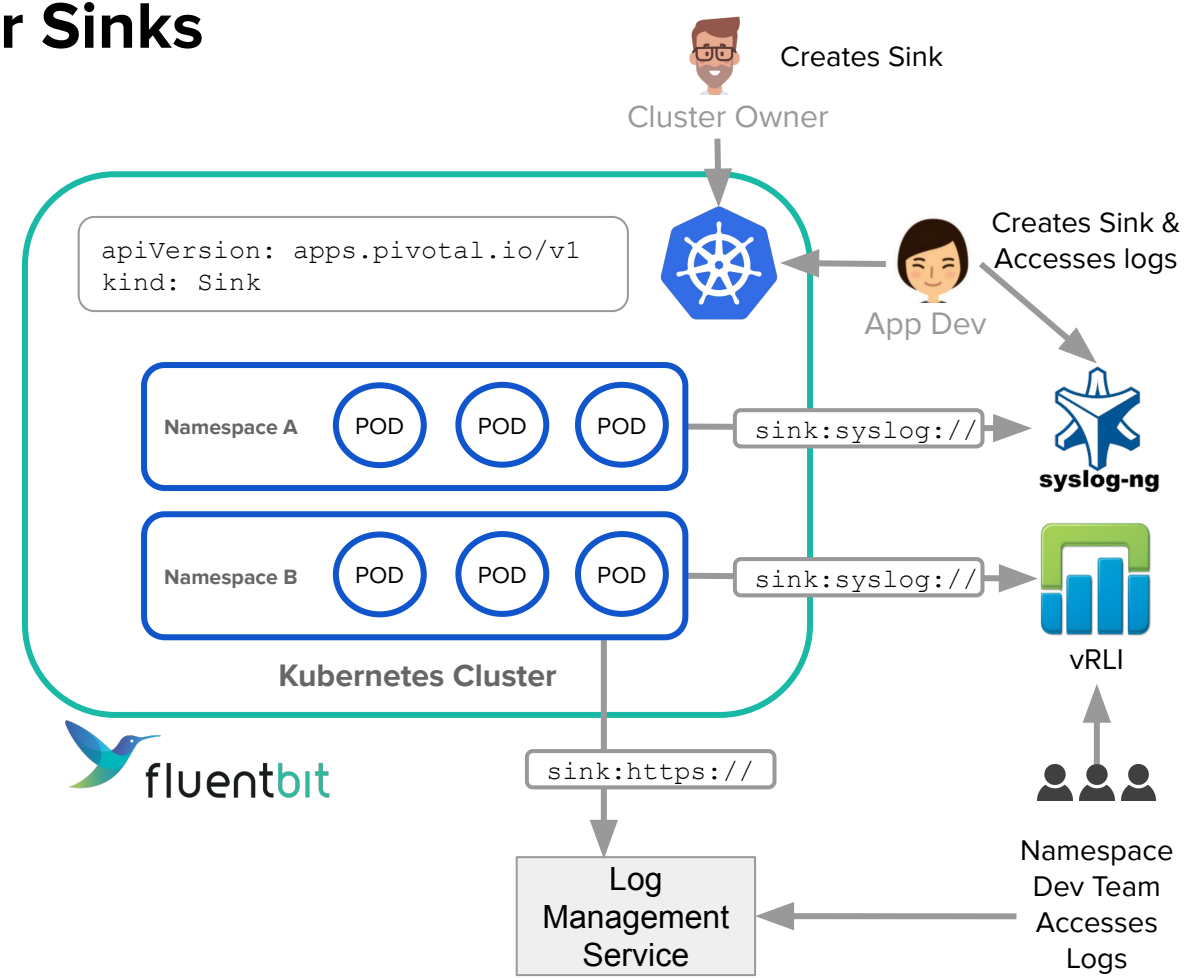
Namespace or Cluster Sinks

Apply to namespace

```
kubectl apply -f sink.yml
```

sink.yml

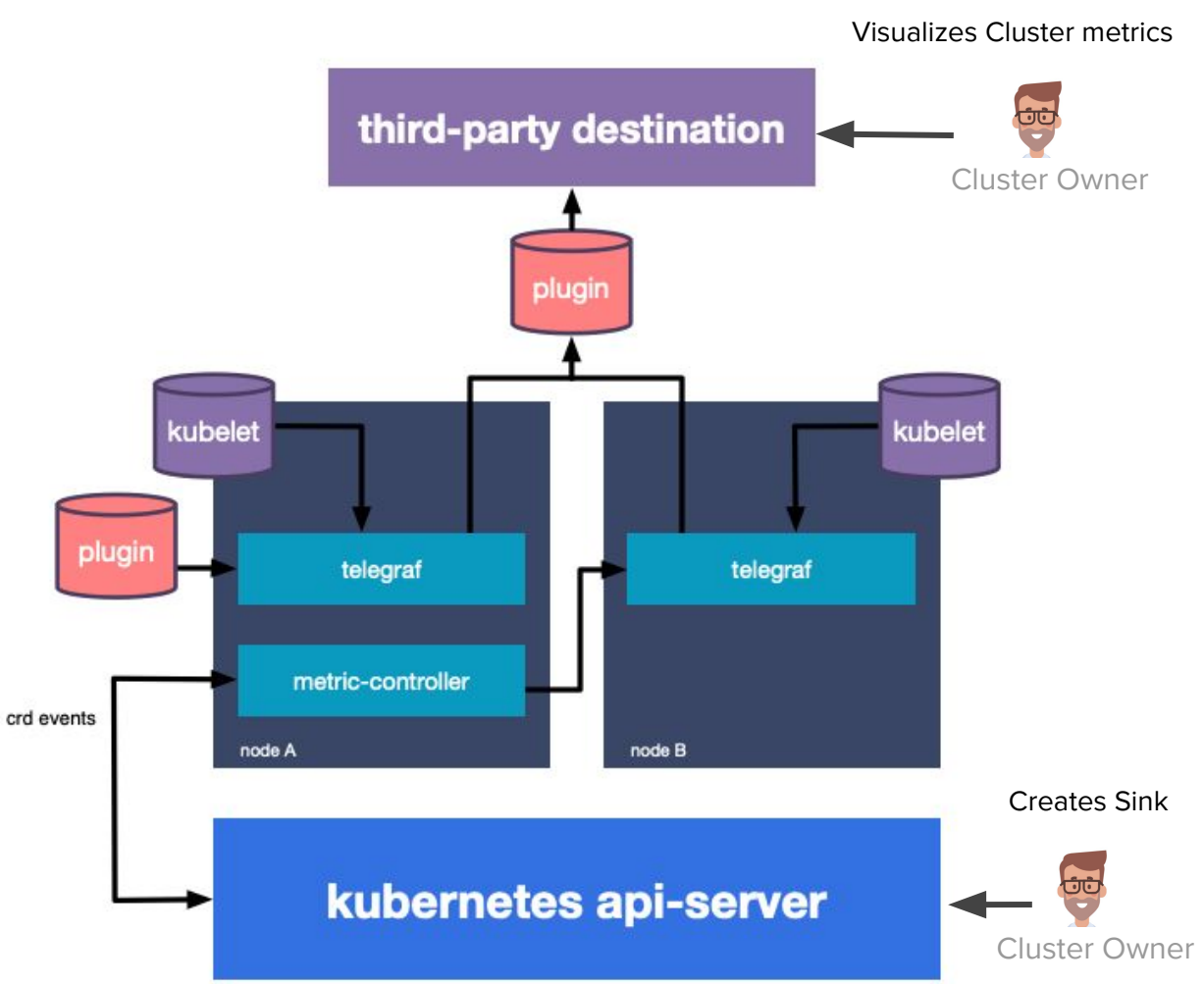
```
apiVersion: pksapi.io/v1beta1
kind: Sink
metadata:
  name: sink
  namespace: default
spec:
  type: syslog
  host: XXXXX
  port: XXXXX
  enable_tls: true
```



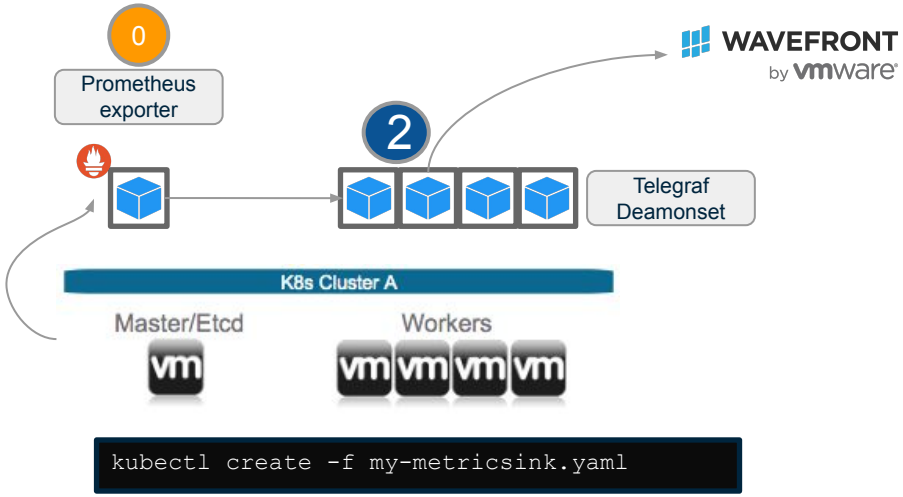
Operations and Observability: Metrics Sinks

Metric Sink collects and writes metrics from a cluster to specified outputs

Supports Telegraf input/output plugins



ClusterMetricSinks




```
apiVersion: pksapi.io/v1beta1
kind: ClusterMetricSink
metadata:
  name: node-exporter
spec:
  inputs:
  - type: prometheus
    urls:
    - http://my-release-prometheus-node-exporter.oratos:10536/metrics
  outputs:
  - type: wavefront
    url: https://metrics.wavefront.com
    token: 123456example
```

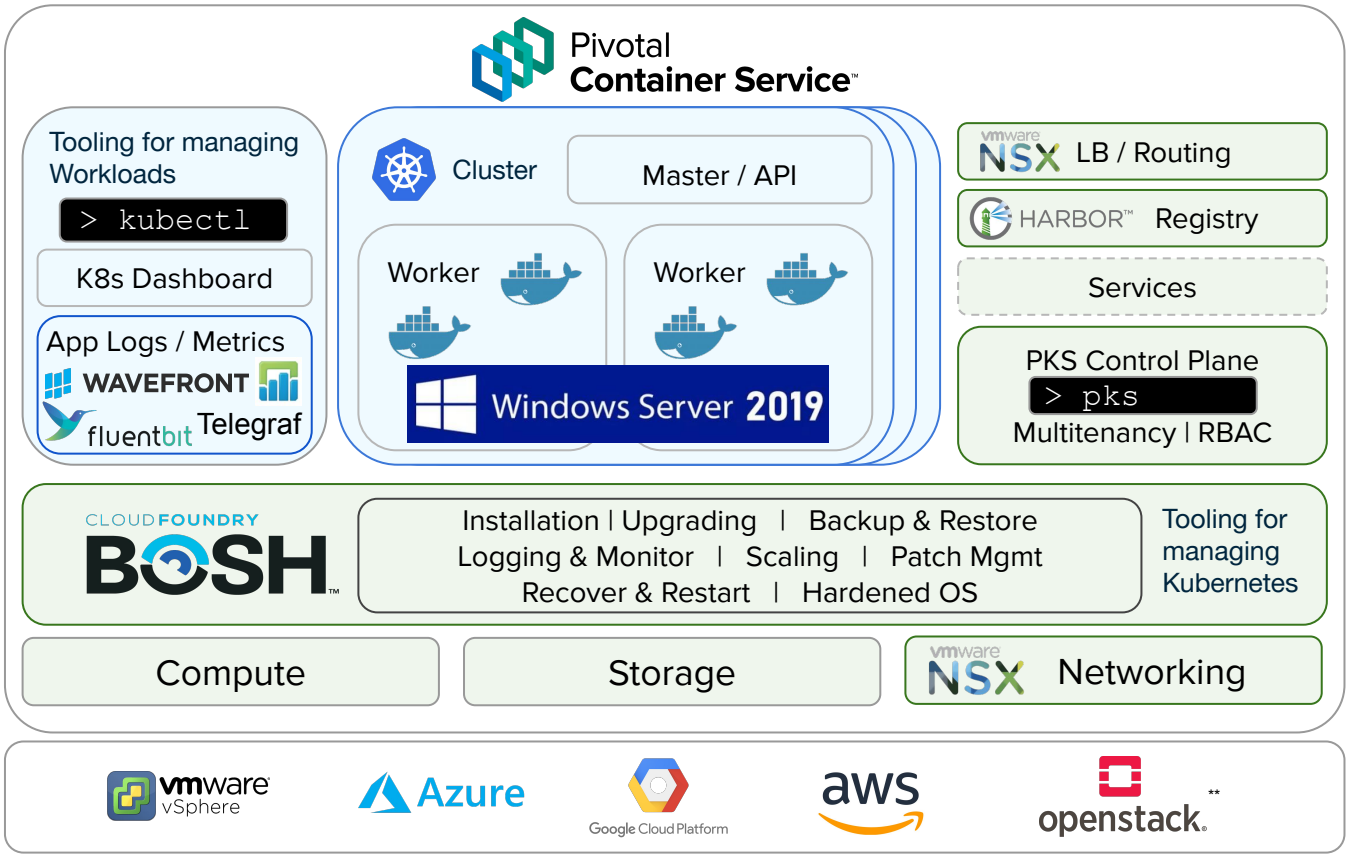
Value

- Collects and writes metrics from a cluster to specified outputs using input and output plugins.

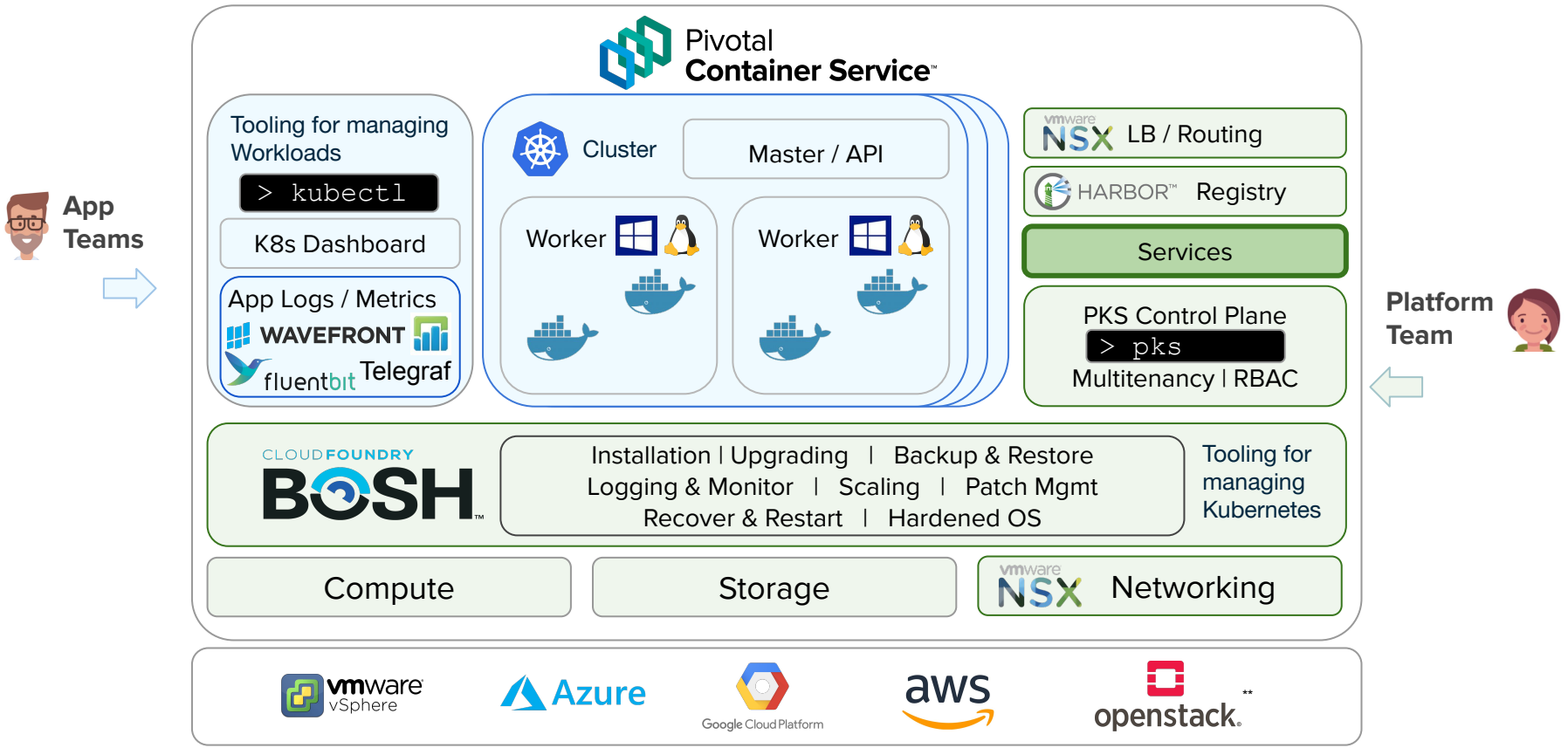
Tech Details

- Implemented as a K8s CRD
- Leverages Telegraf
- Supports Telegraf input/output plugins
- Ships with a default K8s Metric Input plugin

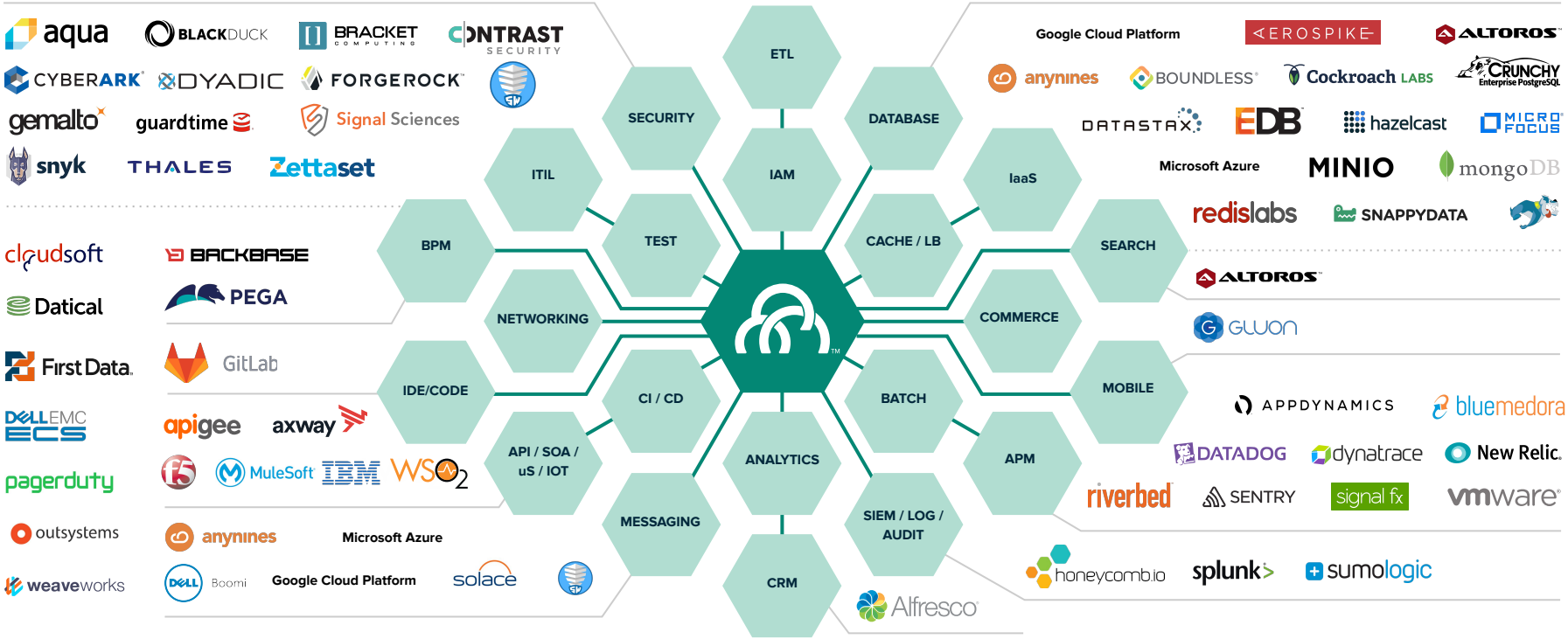
Windows Worker Nodes



Services


Pivotal
Container Service
App
Teams
Tooling for managing Workloads
> kubectl
K8s Dashboard
App Logs / Metrics
WAVEFRONT
fluentbit
Telegraf
Cluster
Master / API
Worker
Worker
vmware NSX
LB / Routing
HARBOR
Registry
Services
PKS Control Plane
> pks
Multitenancy | RBAC
Platform
Team
CLOUD FOUNDRY
BOSH
Installation | Upgrading | Backup & Restore
Logging & Monitor | Scaling | Patch Mgmt
Recover & Restart | Hardened OS
Tooling for managing Kubernetes
Compute
Storage
vmware NSX
Networking
vmware vSphere
Azure
Google Cloud Platform
aws
openstack

ISV Ecosystem Momentum Drives Platform Advantage



Pivotal

Platform Team Delivering Real Value

Developer Productivity

- Accelerate feedback loops by improving delivery velocity
- Focus on applications, not infrastructure
- Give developers the tools and frameworks to build resilient apps

Operational Efficiency

- Employ 500:1 developer to operator ratio
- Perform zero-downtime upgrades
- Runs the same way on every public/private cloud

Comprehensive Security

- Adopt a defense-in-depth approach
- Continuously update platforms to limit threat impact
- Apply the 3 R's → repair, repave, rotate

High Availability

- Run platforms that stays online under all circumstances
- Scale up and down, in and out, through automation
- Deploy multi-cloud resilience patterns

Pivotal Build Service

What do Buildpacks Do in CF?

A buildpack's primary role is to

- Inspect the source code
- Determine any dependencies that will be required to compile and/or run the app
- After the app is staged, the resulting app droplet is ready to be scheduled to run

Buildpacks Automatically Configure Frameworks & App Dependencies

Building blocks for teams to create a repeatable and reusable automated pipeline for upgrading and installing PCF foundations.

- Supports the most common enterprise frameworks & runtimes
- Proven, large-scale adoption
- Increased developer productivity
- Boost security and minimize risk
- Good, but could be better...

Java .NET Framework node.js php GO

Pivotal

What We've Heard from Customers

"I want to use buildpacks in my local dev environment."

"I want to use buildpacks for all of my workloads."

"I want the same security patching I get from buildpacks but for docker images."

"I want faster builds."

"I want a better experience when I promote apps between environments."

Cloud Native Buildpacks (CNB) Bring Developer Productivity to K8s

Buildpacks.io

Pluggable, modular tools that translate source code into OCI images.

- Portability via the OCI standard
- Greater modularity
- Faster builds
- Reproducible image builds
- Unprivileged containers
- Collaboration with Heroku
- **CNCF Sandbox project**

Pivotal Build Service: CNB + Enterprise Features

Automated Image Updates

- Declarative configuration model
- New images are delivered to your registry whenever configuration falls out of sync.
- Consistent and up to date container images.

Consistent and automated build process

- No more “black box” containers!
- Reduce human dev-ops toil
- Remove burden of dependency patching from the product teams

Operator Control

- Restricting buildpack usage in the apps they supervise.
- Create build configurations for different groups of developers within the org.
- These configs would govern the buildpacks that any given dev is allowed to use.

Declarative Configuration Model:

Tell build service what you want your app to look like by creating an image configuration and build service will build against it and keep it up to date when new dependencies are available.

Pivotal Build Service

Pivotal
Build Service

What the future holds

Alpha/Beta and refinement (02/2020)

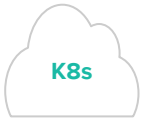
Enterprise PKS

General Availability (05/2020)

Enterprise PKS

PBS 1.1 Q2 Calendar 2020

GA “Nice to have features”



Support deployment on other K8s distros

PAS Integration Q2/Q3 Calendar 2020

Pivotal Application Service

Pivotal Build Service: Alpha

Available now!

Enterprise PKS users can...

- Declare an image configuration -- build service will continuously ensure that the corresponding container image stays up-to-date with the latest source code, language runtimes, and OS patches
- Provide source code (or JARs) via direct upload **or** via a git repository URI; Git branches and tags are monitored for updates automatically
- Analyze detailed metadata associated with each image build, including a bill-of-materials that describes all software contained in the image
- Specify build-time environment variables
- Deploy images produced by build service to any platform that accepts Docker images (e.g., k8s or Cloud Foundry)

kpack: A K8s-native Way to Build and Update Containers

kpack users can...

- Utilize Custom Controllers to automate container image builds using the `kubectl` CLI
- Consume Build Service's container building and declarative logic functionality as a generic component -- like project Riff and Azure Sprig Cloud!

Pivotal Build Service: Beta (February, 2020)

Enterprise PKS users can...

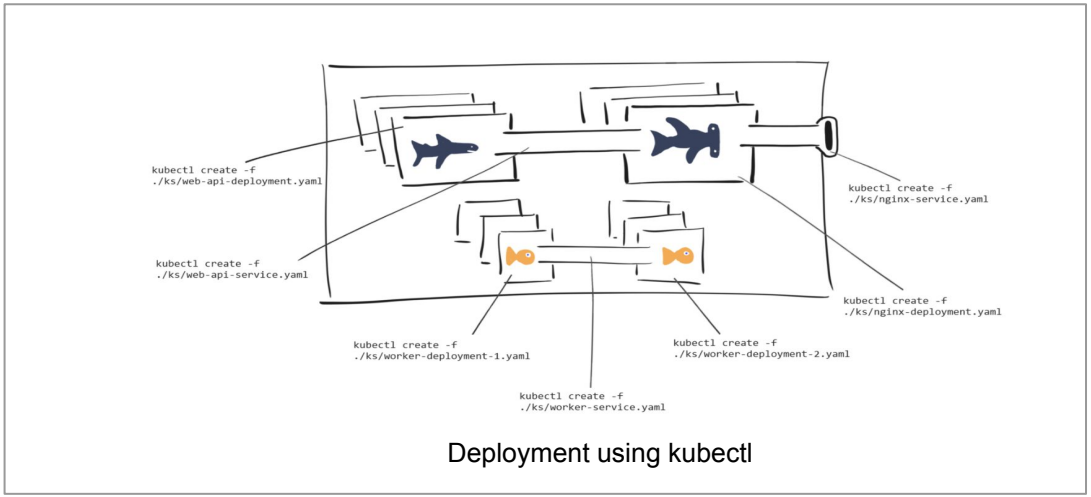
- Create build configurations using modular Cloud Native Buildpacks. A build configuration provides granular control of the software stacks that are permitted in each built image.
- Utilize access management functionality that's backed by K8s RBAC instead of UAA
- List user/LDAP group membership in a project
- List projects of which they are members

Helm

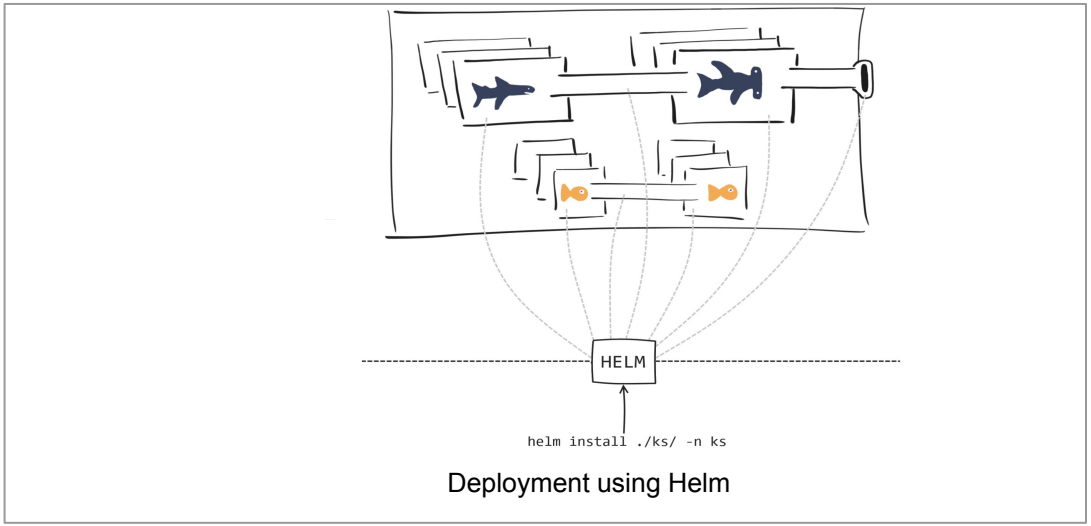
Overview

- Helm is the first application package manager running on top of Kubernetes.
- It allows describing the application structure through convenient helm-charts and managing it with simple commands.

Why Helm



Deployment using kubectl

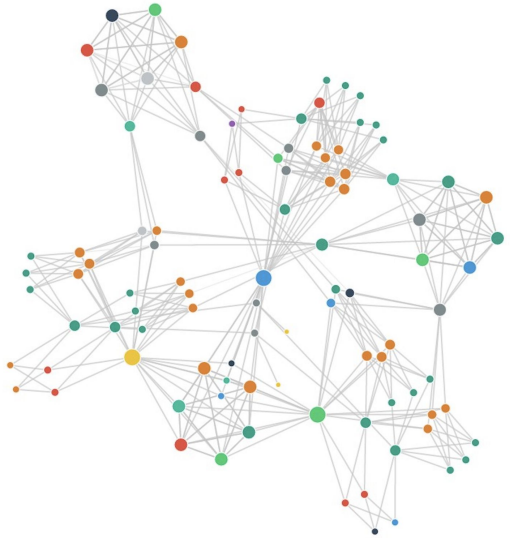


Deployment using Helm

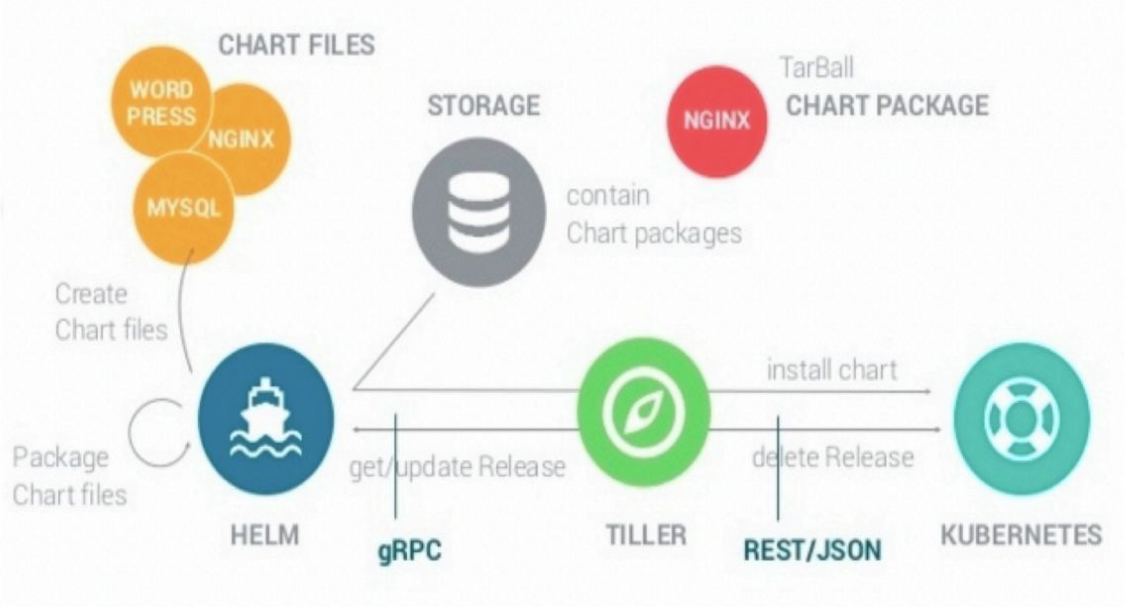
Why use Helm

- Quick app portability
- Better testing
- Easy dev onboarding
- Rollbacks are easy

Deploy CRAZY microservice architectures.



Helm Architecture



Helm Charts

- Helm manages Kubernetes resource packages through Charts.

What is a Chart?

A chart is a set of information necessary to create a Kubernetes application, given a Kubernetes cluster:

- A **chart is a collection of files** organized in a specific directory structure
- The configuration information related to a chart is managed in the configuration
- Finally, **a running instance of a chart with a specific config is called a release**

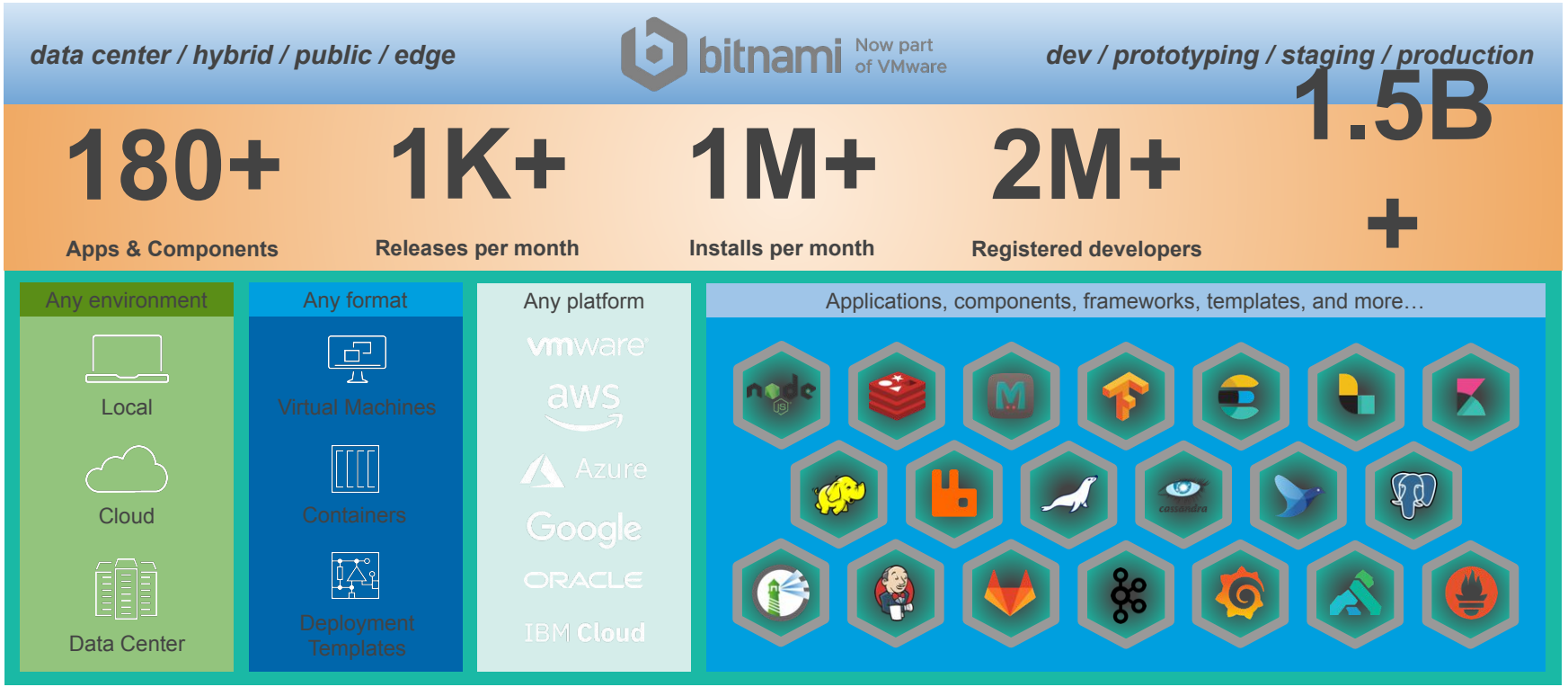
Bitnami and Project Galleon

Loved by **devs.** Trusted by **ops.**

Bitnami enables **multi-cloud, self-service** experiences for developers while simultaneously enforcing IT **compliance, security, and operational best practices**.

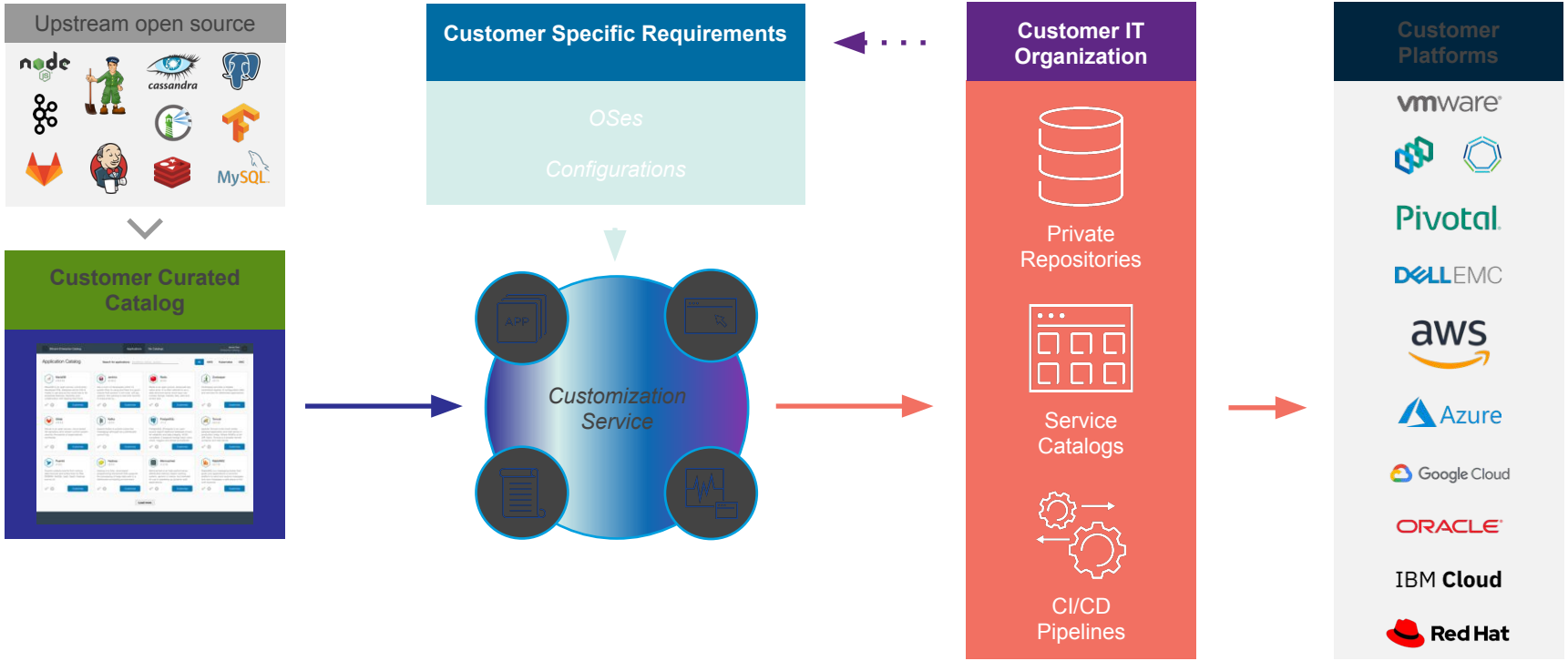
Bitnami's unique perspective

Bringing over a decade of multi-cloud application packaging experience.



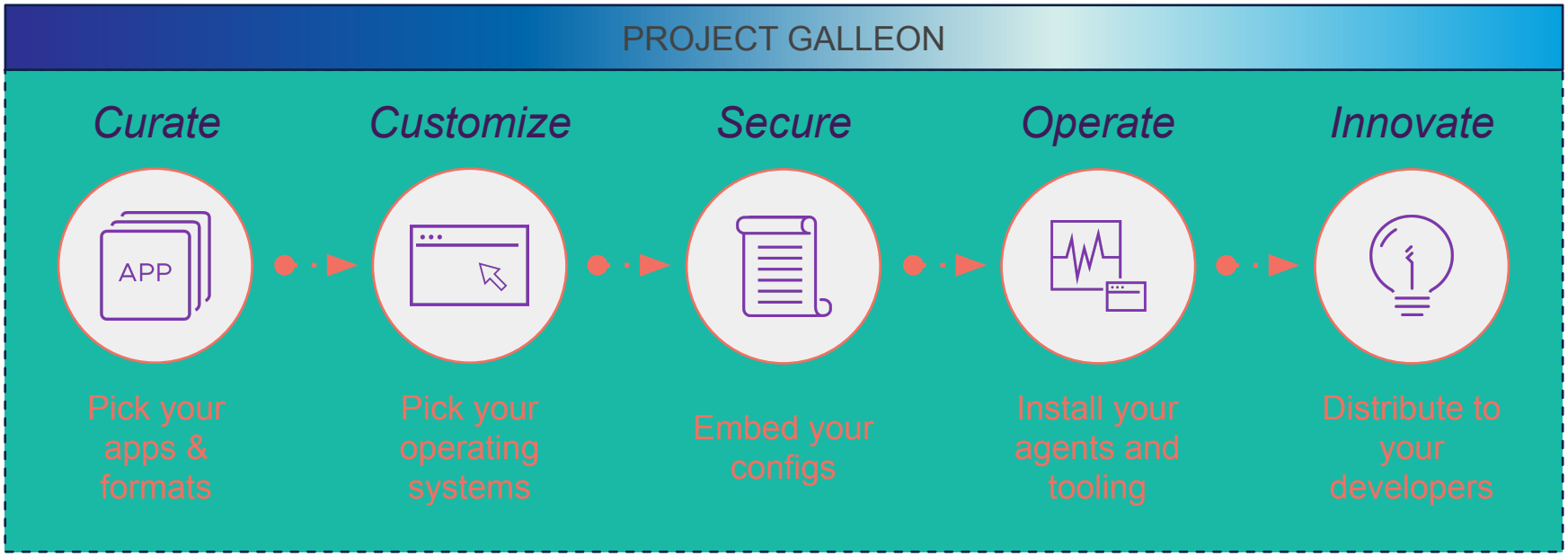
Project Galleon

Continuously maintained, certified, customized components.



Project Galleon

An automated assembly line of continuously maintained and pre-configured components.



Project Galleon

Production ready, customizable, flexible, multi-cloud.

Multi-cloud – support for all major platforms

- Packaged according to best practices and tested across K8s platforms
- Delivered directly to your private repositories ready to deploy

Customizable – best practices, compliance, visibility

- Inject your OS(es), configurations, and desired tooling
- Continuously maintained with upstream updates and patches

Trusted – stability, security, auditability

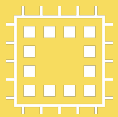
- Powered by Bitnami's proven technology and automation
- Certified with build logs, manifests, scans, and test results

Curated – the right content to the right teams

- Databases, infrastructure tooling, machine learning, analytics, etc.
- Ready to be leveraged for modern application development

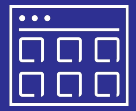
Enabling the organization

High-level use cases and initiatives we can address.



Deployment Standards

Embed uniform security, visibility, and governance policies into distributed development processes.



Developer Self Service

Populate repositories and service catalogs to enable developers with deploy-ready artifacts.

Policy Automation

Ensure security posture and governance by packaging configurations and tools into application components.

Multi-cloud Enablement

Support development on any cloud with platform optimized components, services, and integrations.

Developer Productivity

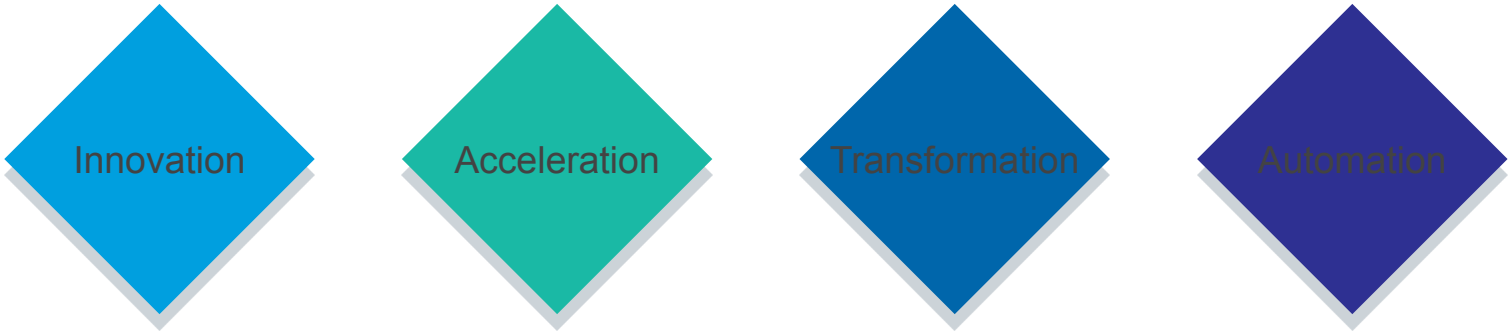
Reduce maintenance overhead, decrease TTM, align teams, and orchestrate development best practices.

Kubernetes Adoption

Accelerate adoption by providing popular, ready to consume, K8s optimized content on demand.

Benefits of Bitnami and Project Galleon

Why you should embrace our approach.



Developers

Innovate faster

Make it easy to discover, experiment, prototype, and iterate with easy to use and up to date software components.

Accelerate TTM

Rapidly bring apps to production by building on top of policy and platform optimized components.

Transform IT

Leverage your resources, increase agility, and support modern development practices and self-service experiences.

Automate trust

Gain visibility, react with confidence, and mitigate risk by embedding programmatic trust in your processes.

Operations

Transforming how the world builds software