99. GSE zExpertenForum der z/OS Arbeitsgruppe

Vitznau, 23.10.2024

z/OS Container Platform

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Statement of direction

On June 23, 2020, IBM announced in

https://www.ibm.com/common/ssi/cgi-bin/ssialias?infotype=an&subtype=ca&appname=gpateam&supplier=897&letternum=ENUS220-033

the following Statement of Direction:

- IBM intends to deliver a container runtime for IBM z/OS® in support of Open Containers Initiative compliant images comprising z/OS software.

- IBM intends to deliver Kubernetes orchestration for containers on z/OS.

- Website: https://www.ibm.com/products/zos-container-platform
- Product ID: 5655-MC3 (5655-MC4 S&S)

✓ z/OS Container Platform, GA March ‘24

✓ z/OS Container Platform, CD1 July ‘24

What is this presentation NOT about?

This presentation is NOT about zCX (z/OS Container Extensions).

Recall zCX is:

– Linux running in a z/OS address space
– Providing either Docker or OpenShift as the container runtime
– Allowing you to deploy Linux on IBM Z containers in that address space

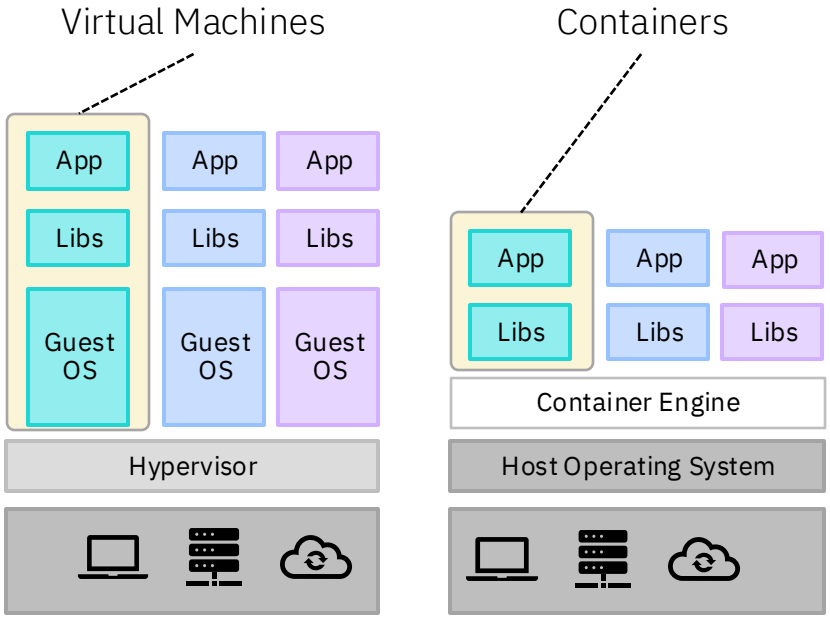
z/OS Containers is about:

– Providing a container runtime (OCI-compliant) that runs natively on z/OS
– Allowing you to build and deploy native z/OS applications as containers
– Subsequently, orchestrate those containers with a Kubernetes orchestration engine.

Comparing containers and virtual machines

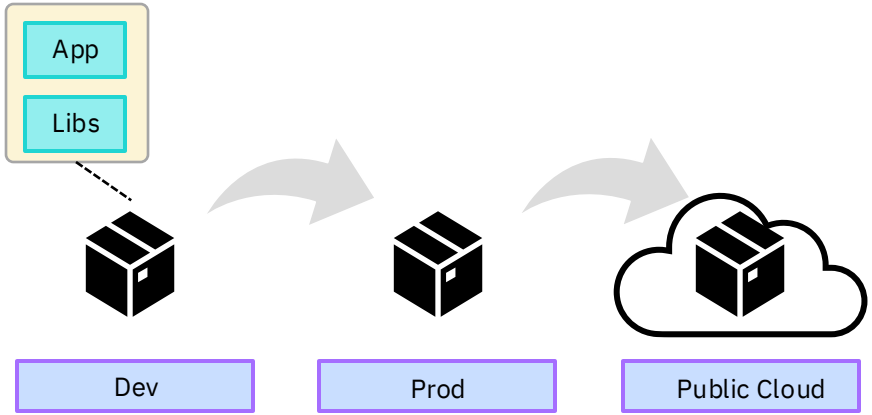
VMs are complete virtualized stacks, each running their own OS, middleware and applications. Their size is typically measured by the gigabyte.

Containers merely package the app and all the files necessary to run; they share a single instance of an operating system (OS). Container images are measured by the megabyte.

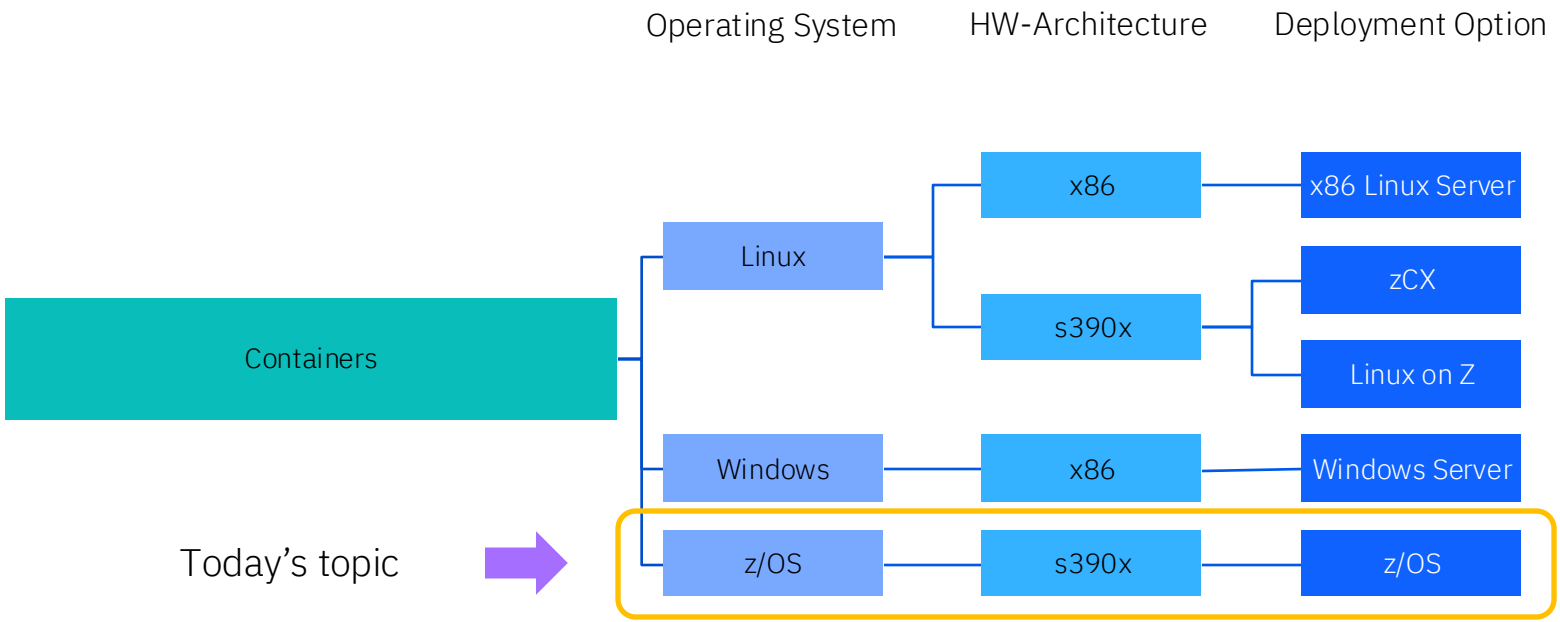


What are containers

- Containers are a packaging mechanism including all application code and required dependencies
- Containers utilize operating system facilities to run applications in isolated environments
- While containers enable decoupling of applications from the environment in which they run, they are operating system and hardware specific
- Easy and consistent deployment on different targets



Container “Genealogy”



Key benefits of containers – skills & consistency

Standardization

Common model for packaging and deployment of applications across the IT landscape

Portability

Consistency for movement across z/OS Dev / Test / Prod

Improved quality

Containers are fully contained including application, middleware, and all dependent configuration information

Agility

Deploy application and provision facilities to support agile development and meet developers' expectations

Isolation / Security

Isolate applications' execution environments from each other, thereby increasing security and integrity

Orchestration

Use industry standard means of deployment and management (ala Kubernetes) across a broad landscape of container-supporting platforms

Containers are based on Images

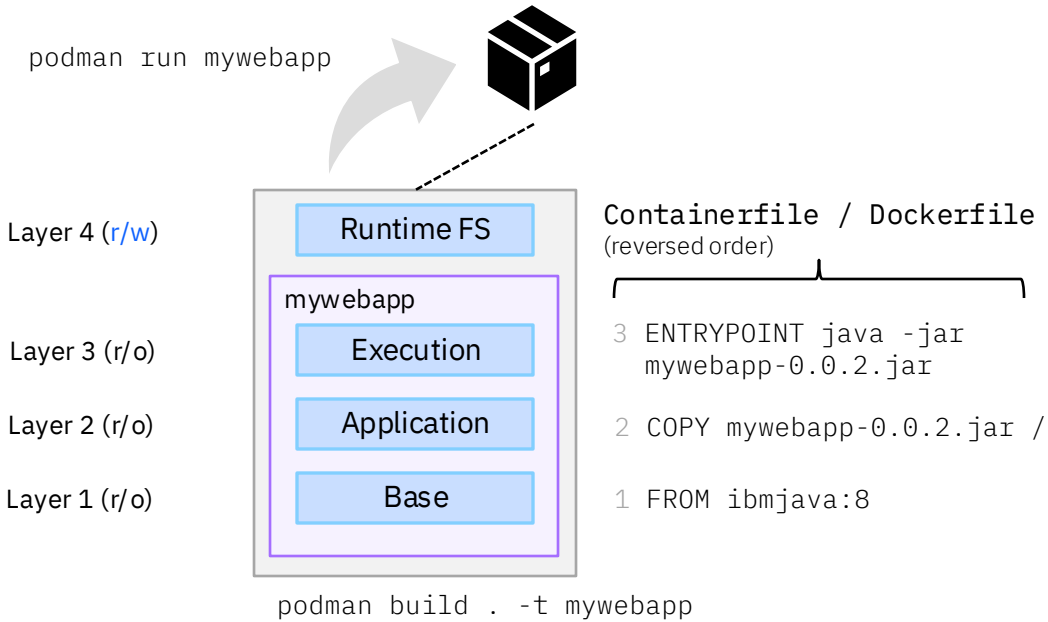
Definition

An image is a lightweight, standalone, executable package of software that includes everything needed to run an application: code, runtime, system tools, system libraries and settings

Images can only be created or read, but not modified - they are immutable

To modify an image, a new image need to be built on top of an existing image

Images become containers at runtime



What are z/OS containers?

z/OS containers run on z/OS isolated from each other through z/OS facilities

z/OS containers provide portability and consistency across z/OS LPARS and environments

Examples

- A newly developed Java / WAS (Liberty) application; will be built and deployed as a container from inception since the application developers come from a distributed background
- Aspirational: A 20-year-old mission critical COBOL application running in CICS® or IMS™ ; it can be containerized so that it can be orchestrated (via Kubernetes) with other cloud native container applications that run on non-z/OS platforms

Enables system programmers to create templates for consumption by developers in a regulated manner

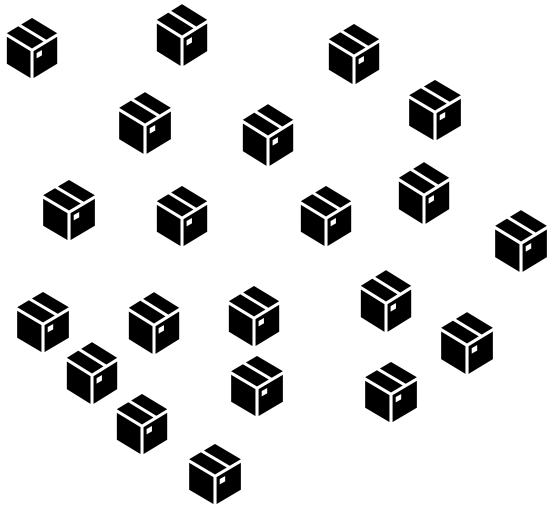
Allows developers to consume defined resources in a self-service model in an isolated, approved environment

How scalable is this?

Start small with a few containers – “ok”

Growing the size – “hmm”

Adding even more – “how do I manage this?”



A solution is needed: Kubernetes

Container orchestration with Kubernetes

Kubernetes is the de factor standard container orchestration platform to manages the life cycle of containers

– Provisioning and deployment

– Availability

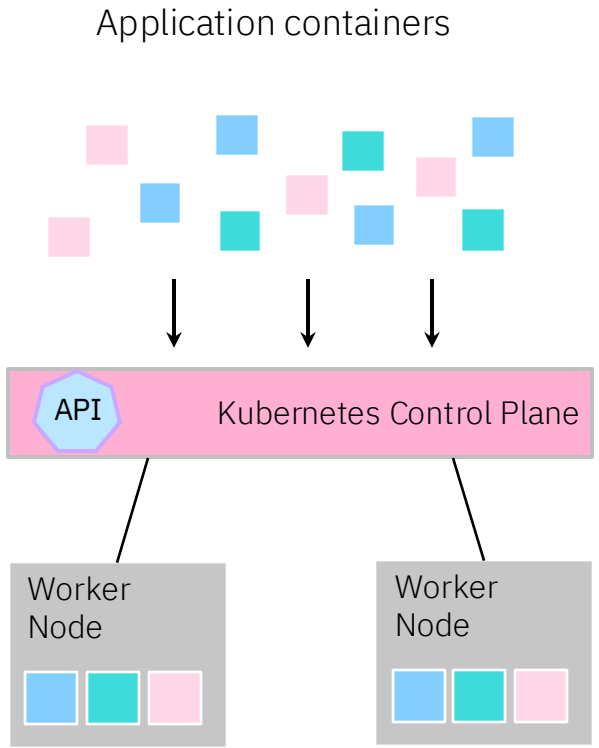
– Scalability

– Scheduling on infrastructure

– Health checks

Facilitates declarative management

Widely available open-source component with a large and rapid growing ecosystem



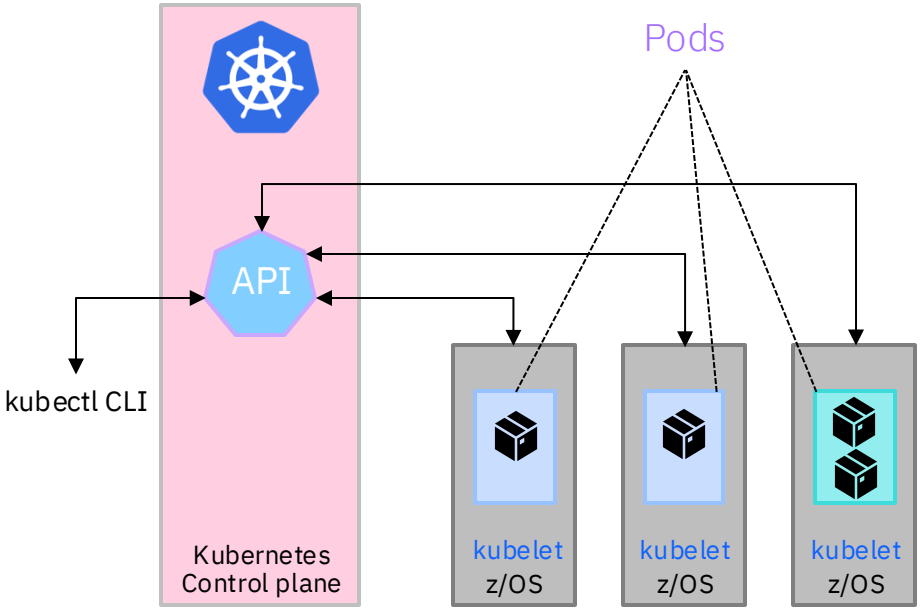
Kubernetes objects

A *Pod* is the smallest deployable unit of computing that can be created and managed in Kubernetes

It represents a single instance of an application

Typically, it consists of a single container

Sometimes it groups multiple, tightly coupled containers that share the same network and storage resources



Kubernetes objects

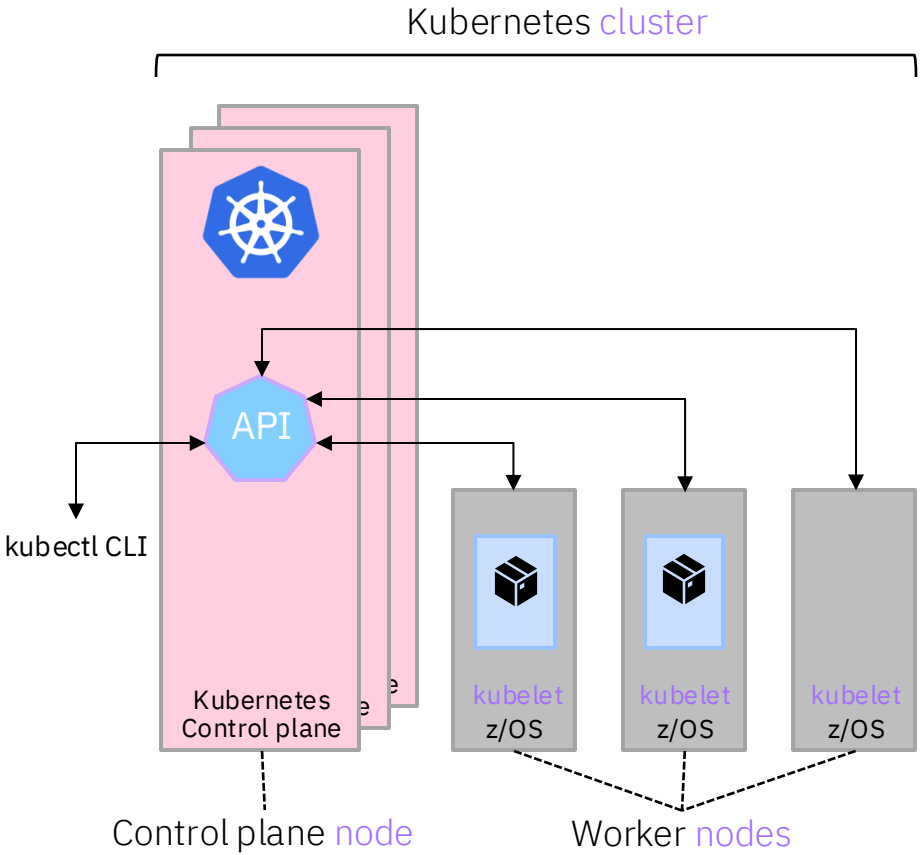
Kubernetes runs your workload by placing containers into *Pods* to run on worker machines, so called *Nodes*

A node may be a virtual or physical machine, depending on the cluster

For z/OS, a node is an LPAR or guest VM running z/OS

A *cluster* is the control plane with its components (API-server, scheduler and more) plus a collection of worker nodes

For HA-reasons, the cluster components typically run on 3 control plane nodes



Kubernetes objects

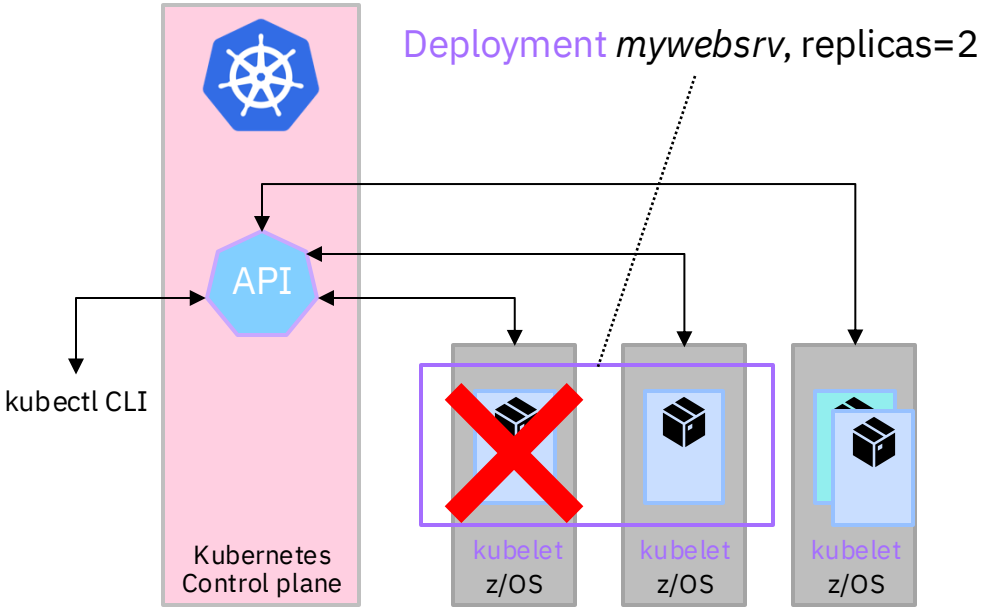
A *Deployment* manages multiple instances of an application, i.e., pods

The deployment declares how many replicas of an application should exist

You can scale the number of replicas up or down, on demand or even automatically

A deployment supports rolling updates while maintaining the availability of the application

Kubernetes manages replicas towards their desired status



z/OS approach in using open-source technologies

Formed under the Linux Foundation

OCI specifies two specifications:
–Image Specification – how to build an image
–Container Runtime – how to run an image in a container

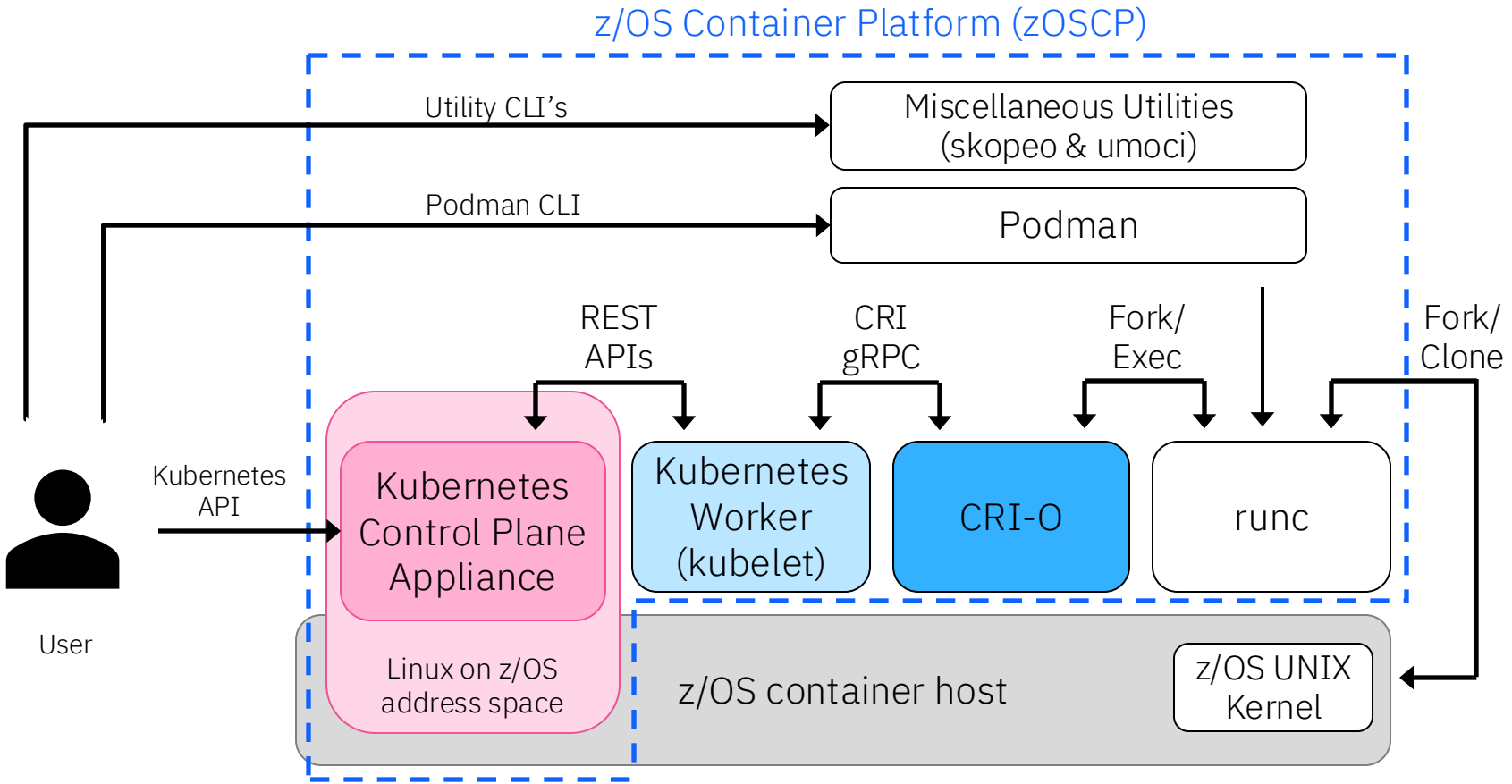
Kubernetes is an open-source system for automating deployment, scaling, and management of containerized applications

CRI-O is an open source, community-driven container engine and is a lightweight alternative to using Docker as the runtime for Kubernetes

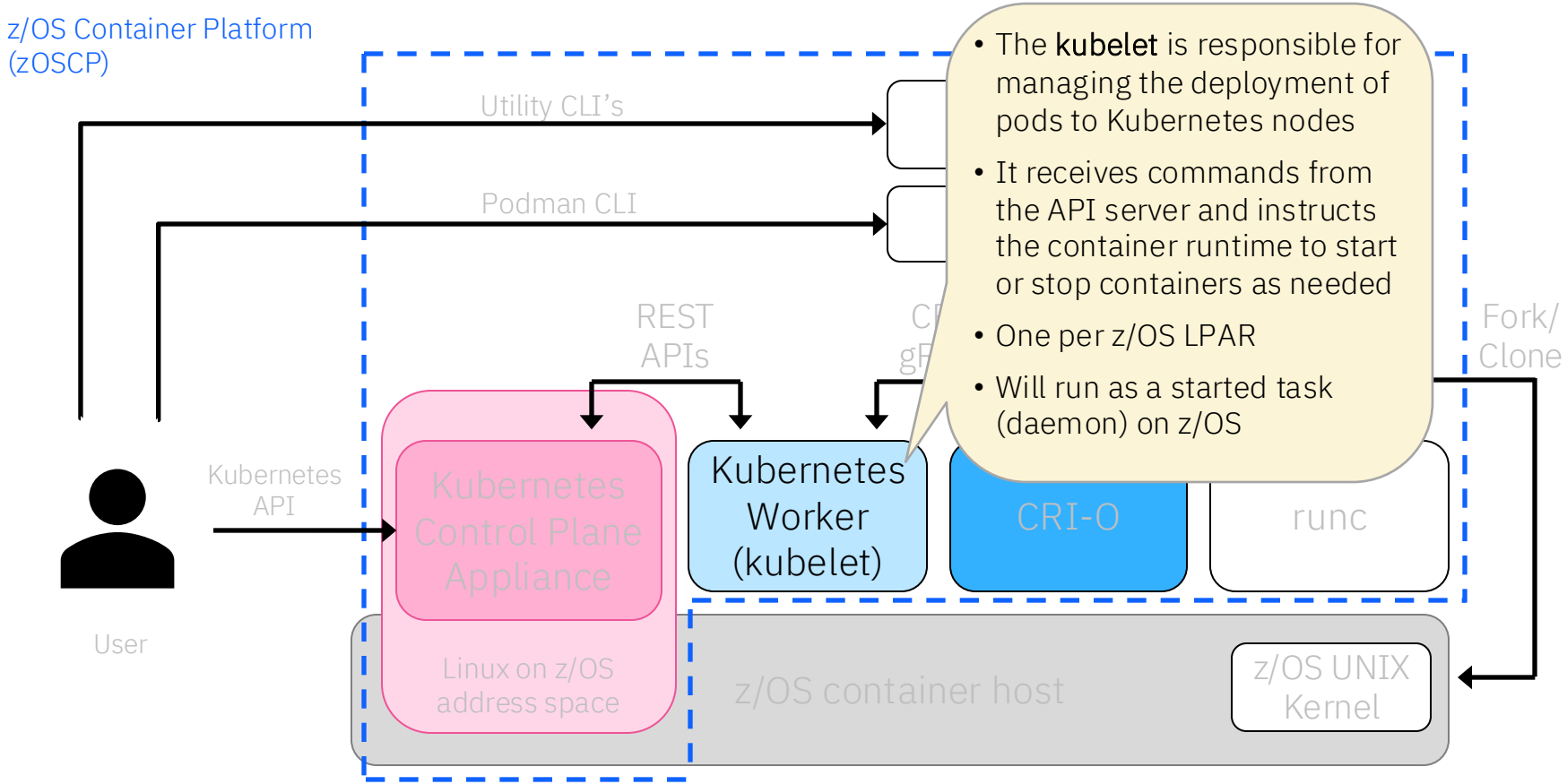
runC is a universal container runtime and a CLI for spawning and running containers according to the Open Container Initiative (OCI) specification

Podman (POD manager) is an open source CLI designed to make it easy to find, run, build, share and deploy applications using OCI-compliant containers and container images

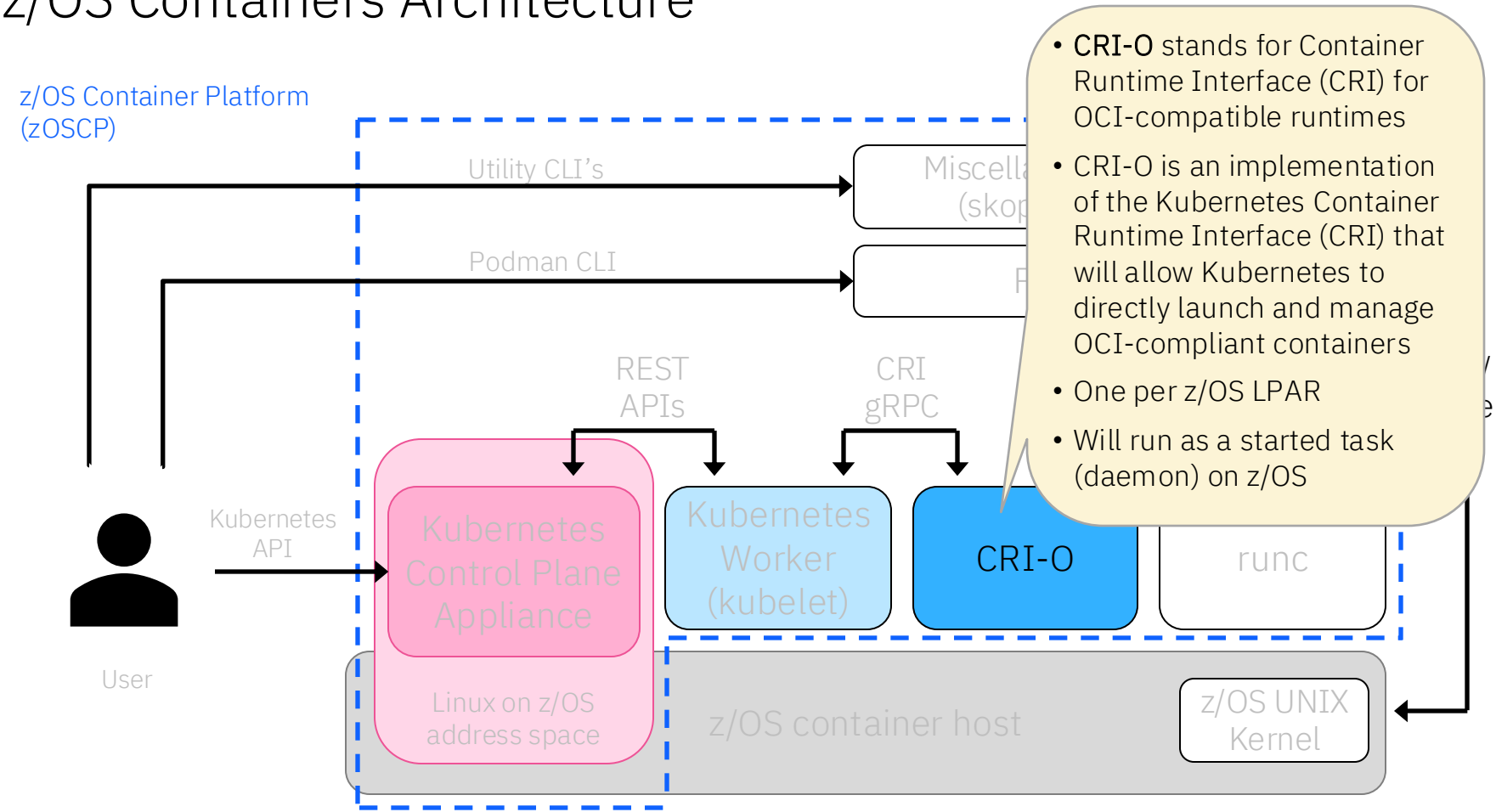
z/OS Containers Architecture



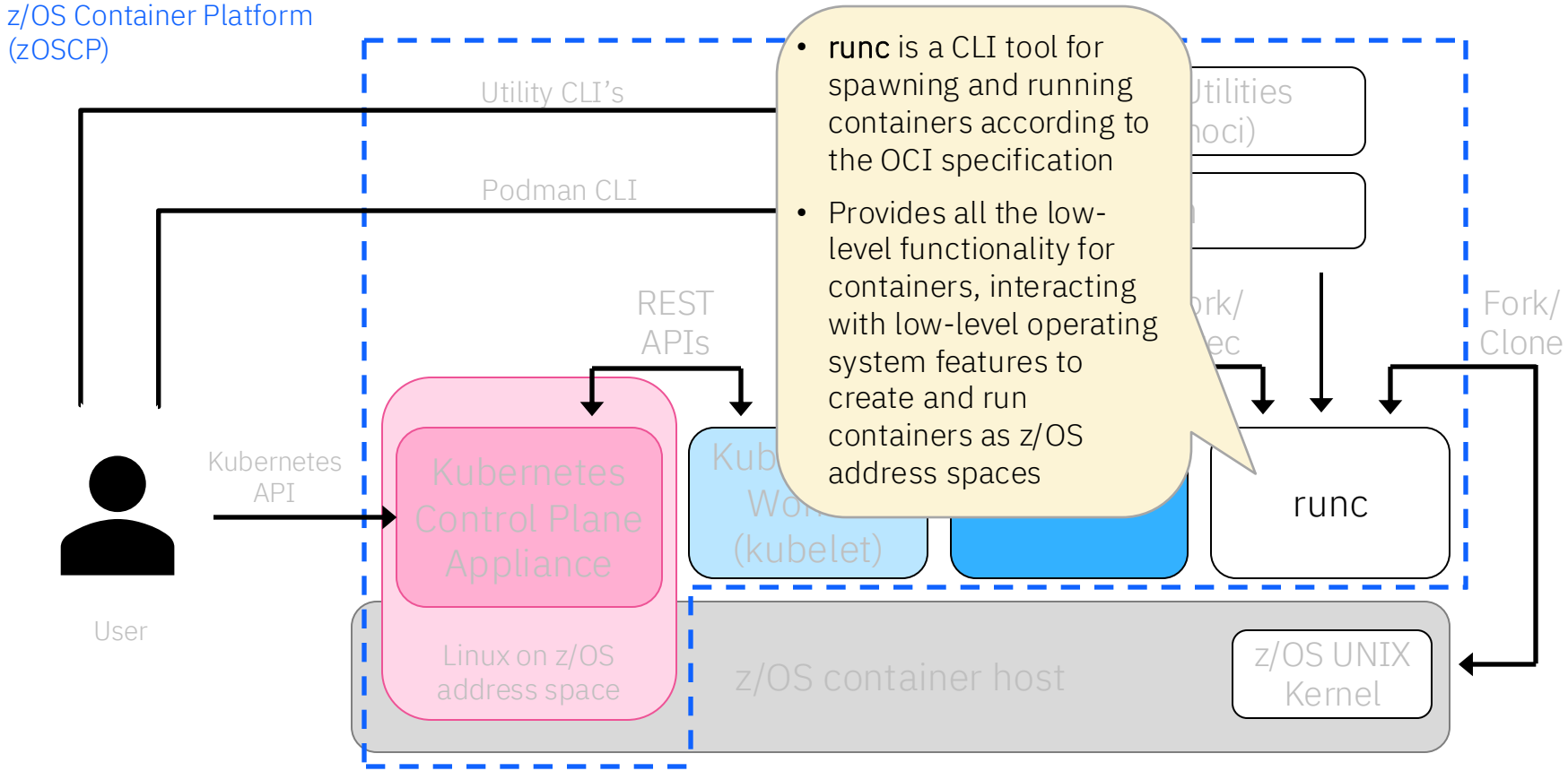
z/OS Containers Architecture



z/OS Containers Architecture



z/OS Containers Architecture



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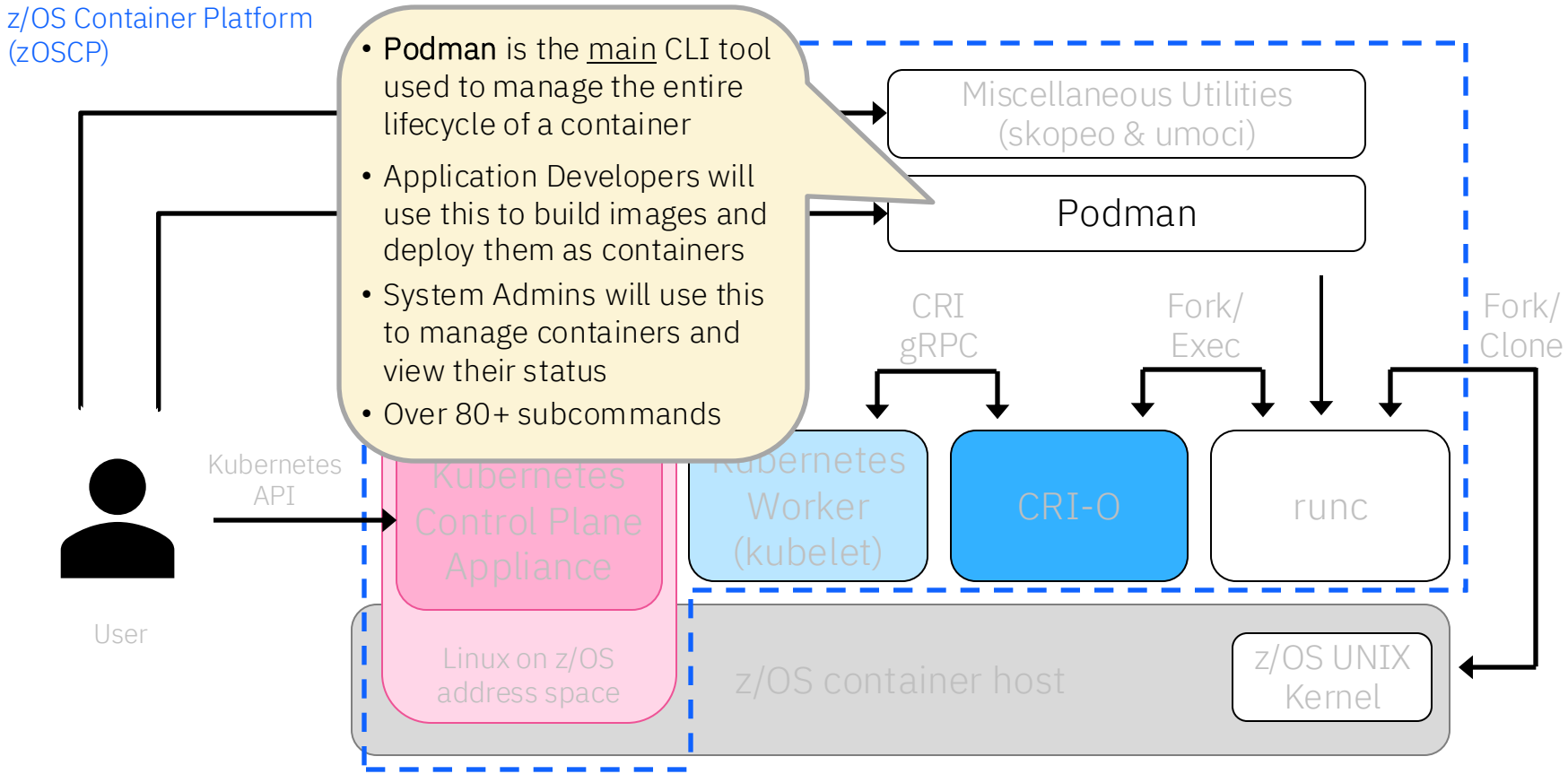
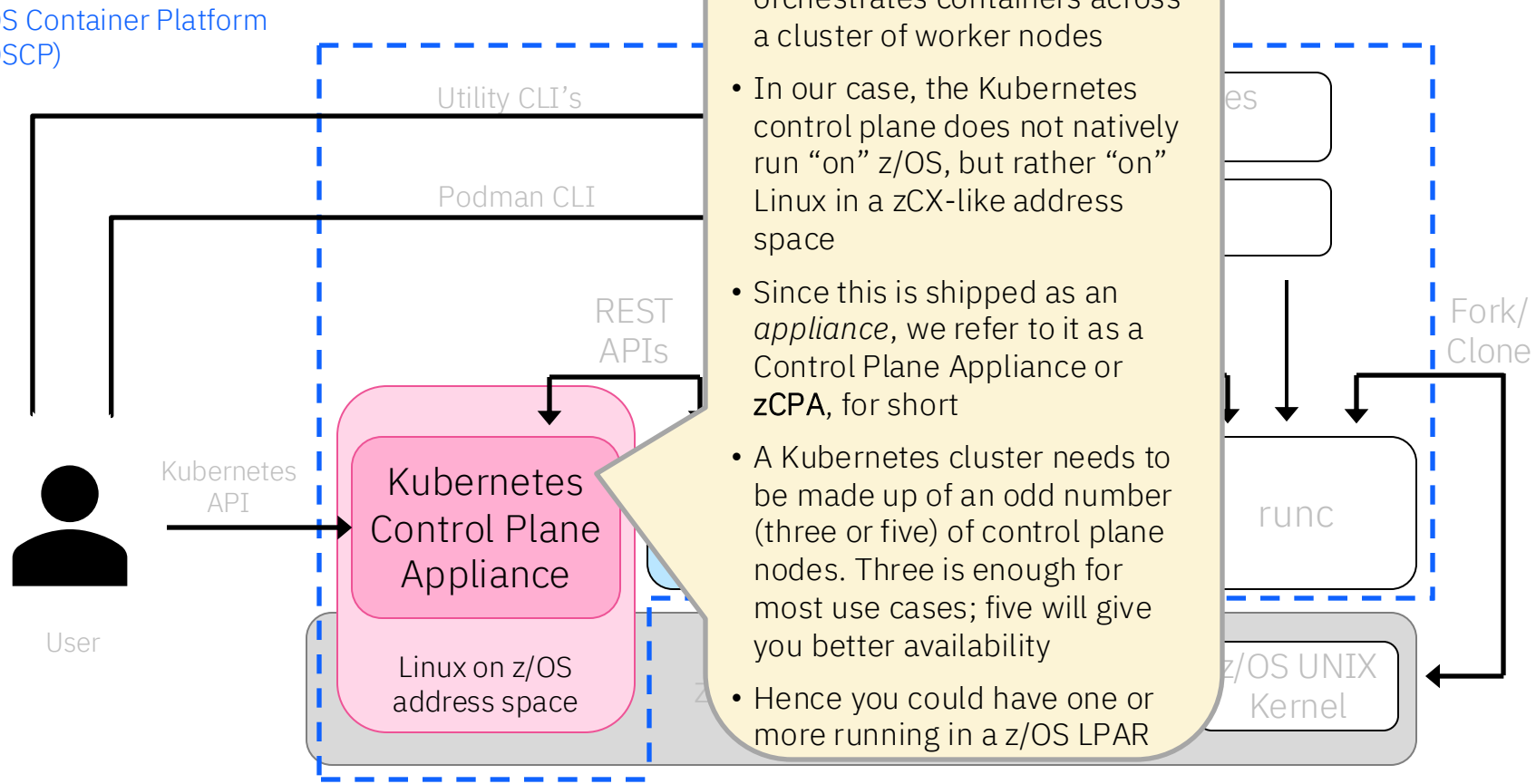


z/OS Containers Architecture



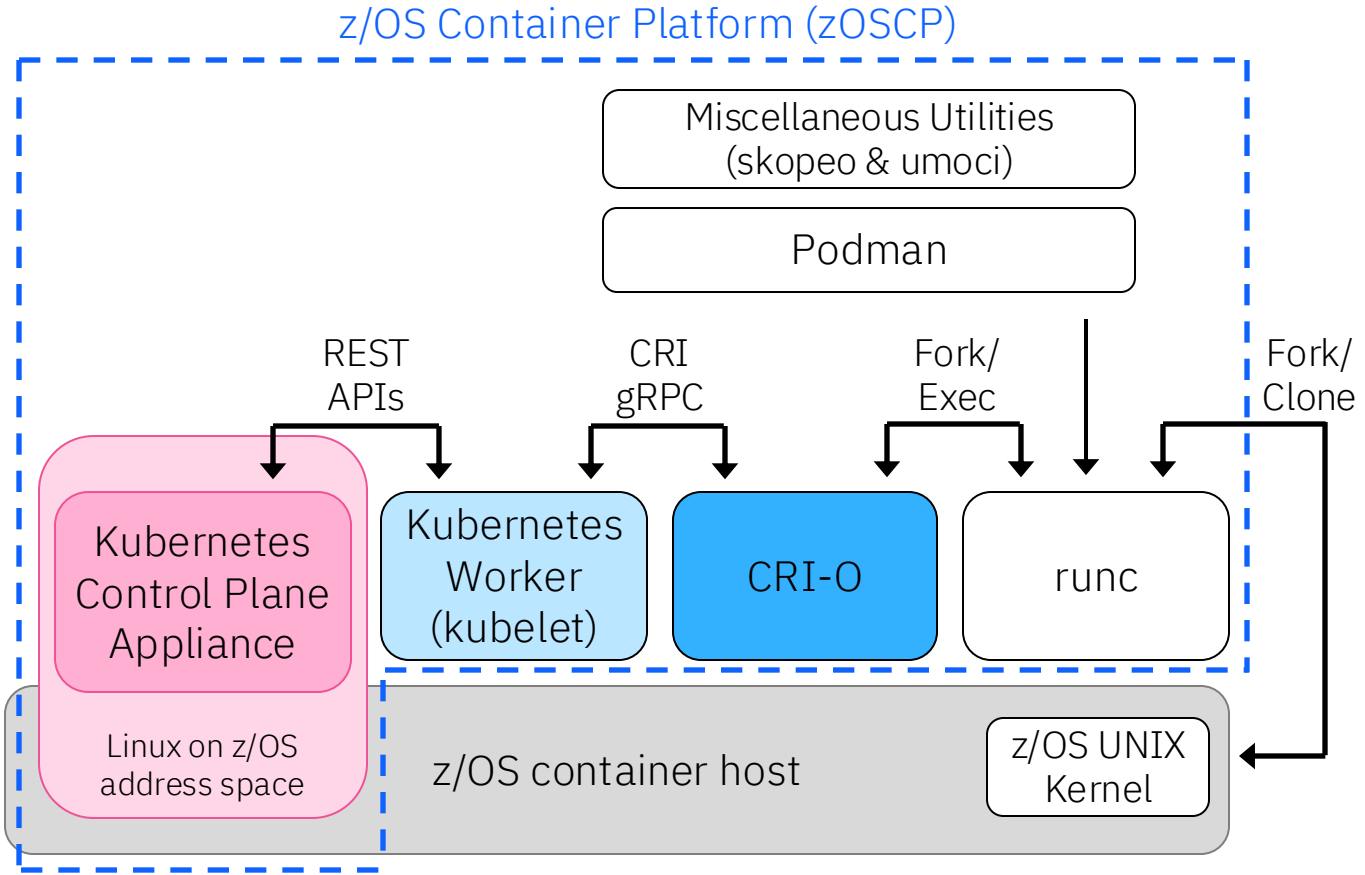
- The **Kubernetes control plane** orchestrates containers across a cluster of worker nodes
- In our case, the Kubernetes control plane does not natively run "on" z/OS, but rather "on" Linux in a zCX-like address space
- Since this is shipped as an *appliance*, we refer to it as a Control Plane Appliance or **zCPA**, for short
- A Kubernetes cluster needs to be made up of an odd number (three or five) of control plane nodes. Three is enough for most use cases; five will give you better availability
- Hence you could have one or more running in a z/OS LPAR

z/OS Container Platform today

July ‘24

z/OS 2.5 and z/OS 3.1 provide among others

- New UNIX System Services syscalls (75)
- Various enhancements to existing syscalls and C-header files
- Linux concepts of namespaces for isolation
- Kubernetes v1.29



zOSCP CD1 Support

- Available with PTFs for the following 12 APARs:
  - OA66262
  - OA66266
  - OA66267
  - OA66268
  - OA66269
  - OA66270
  - OA66361
  - OA66362
  - OA66363
  - OA66364
  - OA66365
  - OA66366
- Available since June 28, 2024

z/OS Container Dependencies provided in z/OS

New Syscalls (75)

- openat()
- openat2()
- syncfs()
- getrandom()
- getentropy()
- listxattr()
- llistxattr()
- lremovexattr()
- lsetxattr()
- removexattr()
- setxattr()
- lgetxattr()
- getxattr()
- flock()
- prlimit()
- umount2()
- nanosleep()
- fgetxattr()
- flistxattr()
- fremovexattr()
- fsetxattr()
- epoll_create()
- epoll_create1()
- epoll_ctl()
- epoll_pwait()
- epoll_wait()
- eventfd()
- fstatfs()
- statfs()
- dirfd()
- wait4()
- futimesat()
- utimensat()
- clock_gettime()
- futimes()
- lutimes()
- strchrnul()
- fdatasync()
- inet_aton()
- pivot_root()
- accept4()
- getline()
- sethostname()
- clone()
- unshare()
- setns()
- prctl()
- pipe2()
- dup3()
- inotify_init()
- inotify_init1()
- inotify_add_watch()
- inotify_rm_watch()
- memfd_create()
- faccessat()
- fchmodat()
- fchownat()
- fstatat()
- linkat()
- mkdirat()
- mkfifoat()
- mknodat()
- readlinkat()
- renameat()
- renameat2()
- symlinkat()
- unlinkat()
- __fchattrat()
- dprintf()
- asprintf()
- vasprintf()
- Linux variant of mount()
- Linux variant of umount()
- pthread_condattr_setclock()
- Linux variant of localtime_r()

Enhancements to existing syscalls & headers

- Implement BPXK_AUTOCVT for AF_LOCAL sockets
- IP_TTL flag for setsockopt() & getsockopt()
- New flags for open()
- Support “e” flag on fopen()
- New flags for socket() & socketpair()
- NAME_MAX in limit.h
- PATH_MAX in limit.h
- NI_MAXHOST in netdb.h
- NSIG in signal.h
- tm_gmtoff in time.h
- new flags on mount()
- Remount on TFS
- new flags on umount()
- Update to gethostname()
- New flags in mmap()
- PROC_SUPER_MAGIC in sys/statfs.h

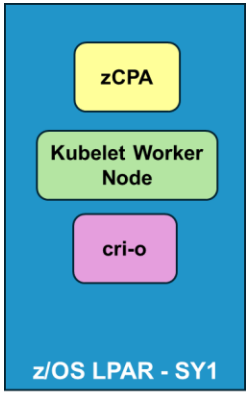
Linux Concepts

- IPC namespace
- PID namespace
- UTS namespace
- Mount namespace
- Union file system
- /proc file system
- Namespace utilities
  - nsenter
  - unshare
  - lsns

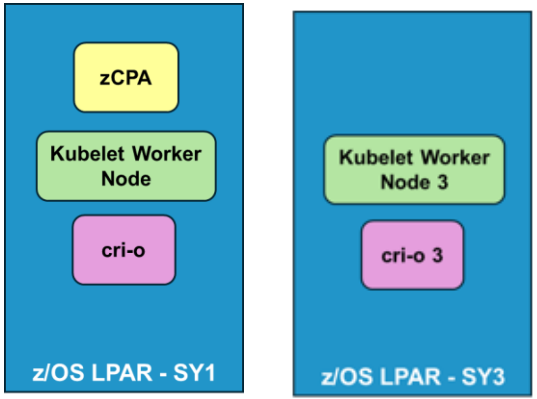
z/OS Unique Technology for Containers

- WLM support for new Service Class
- Hybrid networking support
- Update to netstat utility

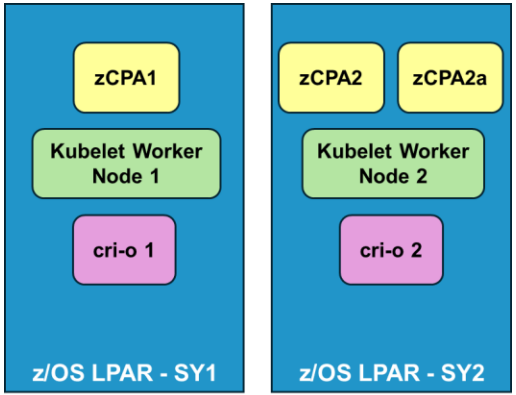
Possible IBM zOSCP Configurations 1 of 2 (including Variations thereof)



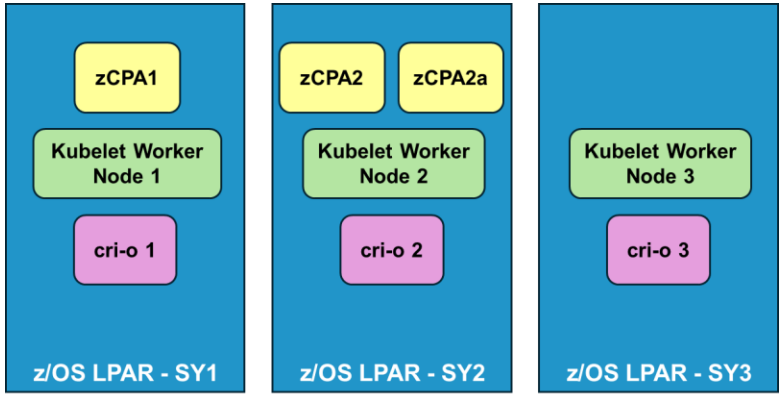
Single Instance Configuration



Single Instance Configuration+

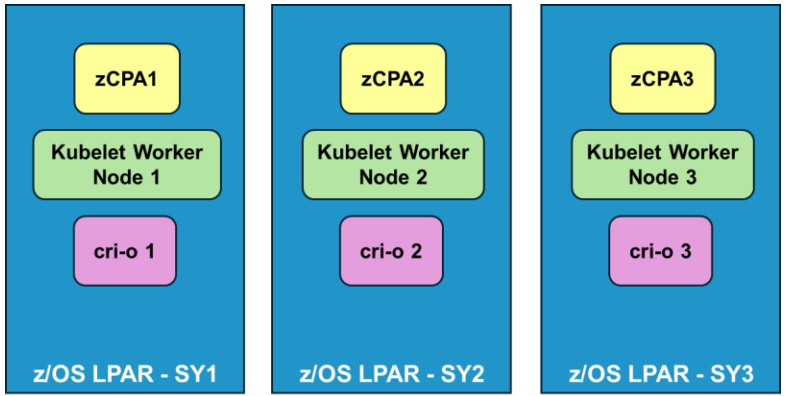


Unbalanced Configuration

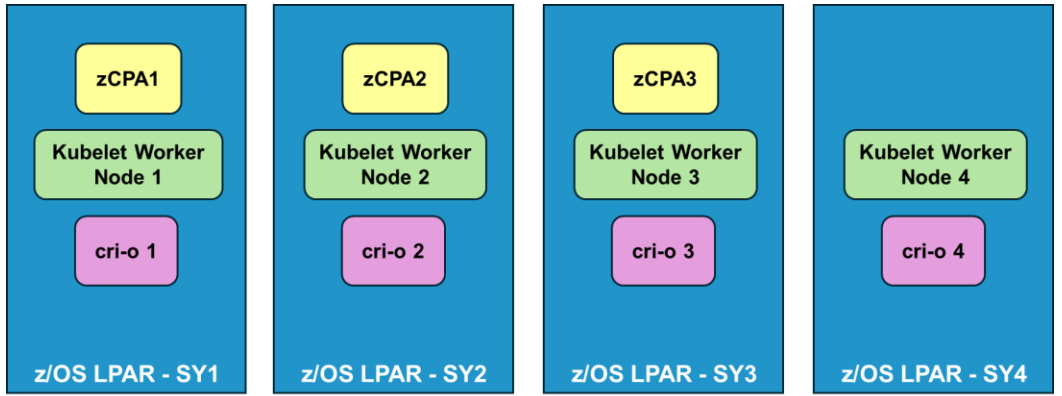


Unbalanced Configuration+

Possible IBM zOSCP Configurations 2 of 2 (including Variations thereof)



Balanced Configuration



Balanced Configuration+

Implementation

Application running in containers will be address spaces on z/OS.

z/OS has implemented the Linux concept of namespaces for isolation and virtualization. This is above and beyond the isolation already available on z/OS for address spaces.

- PID namespace - allows a process running inside a PID namespace to seem as if it is the only process running in that space and therefore would have a PID=1. Of course, from the outside (of the PID namespace) it will have a real PID number, but on the inside, it will have a PID of 1.
- IPC namespace - will allow Inter-Process Communication (IPC) to only happen between the processes running within that IPC namespace. The types of communication we are talking about are the POSIX IPC communication schemes: semaphores, shared memory and message queues. Cross-memory and common storage are not affected.

Implementation (*cont.*)

UTS namespace - UNIX Time Sharing namespace allows a process to set the hostname of that environment. This is needed because the container runtime will assign a random ID to this but can be over-ridden in the future.

Mount namespace - Essentially allows for a scoping of the file system that the processes within that mount namespace will be able to see. To establish a mount namespace, you also need to have pivot_root() capability (essentially another flavor of chroot()) whereby you are changing the root directory to a sub-portion of the file system hierarchy that has just been established. That will be file system view the process(es) will have. The other new capability that is needed for mount namespaces is bind mounts, whereby you mount things that are outside of the mount namespace file system to inside of the namespace.

Implementation (*cont.*)

Not implemented on z/OS

- cgroup namespaces - We don't have cgroups on z/OS and so having a cgroup namespace on z/OS doesn't make sense. However, we have integrated with WLM, whereby one could specify a specific service they want the process (address space of a container) to run under, or if set up, we would run it in a specific WLM service class created just for containers. If nothing is set up, then we will take the lowest service class (batch).
- Network namespace - There is no network namespace support on z/OS. However, upon creation of a container or a pod, a dynamic VIPA is assigned to that new instance and that gives the appearance of network isolation which is very similar to what network namespaces provide on Linux.
- User namespace - We chose not to implement a user namespace, because we didn't want to erode the concept of "centralized security" on z/OS. We want applications running in containers to be governed by the same security database, as when applications would be running outside containers.

- We may need to invent new z/OS-specific namespaces in the future.

How to get started?

Development & Test

- Leverage an isolated self-service environment for development and test
- Employ enterprise-wide tool and process standardization enabling parallel development and continuous integration
- Spin up/down containers to introduce new features and facilitate changes

Access current base images (z/OS, Java, Golang, z/OS Connect)* from IBM Container Registry (ICR)

Create your own application image on top of a base image using `podman` or `umoci`

Use `skopeo` to maintain your own image registry

Containers can be started and stopped using `podman` from the UNIX System Services command line

* More images will be added over time

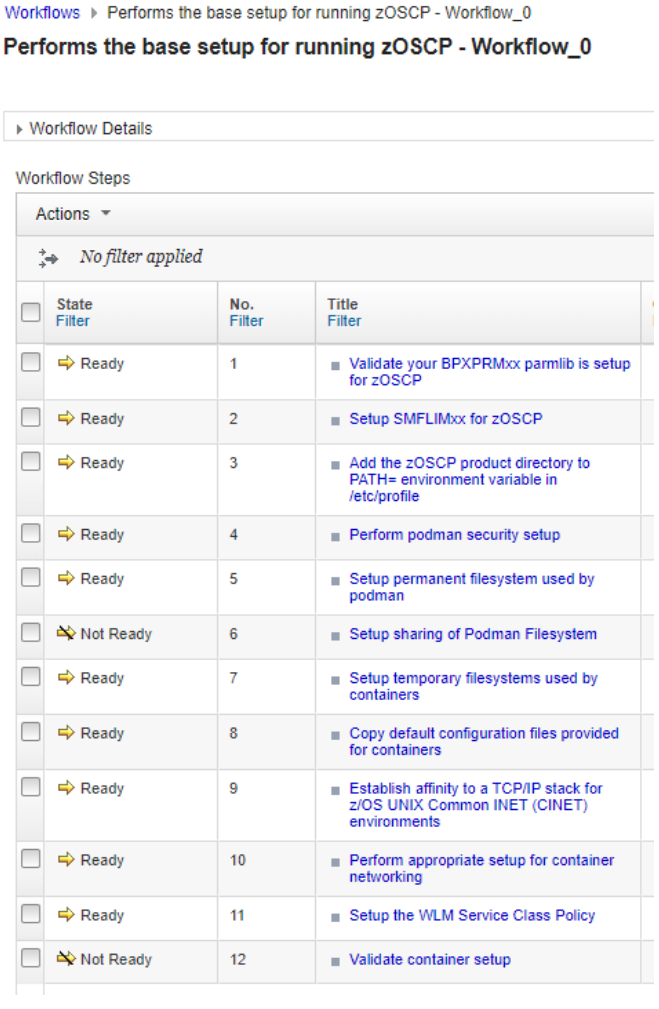
Installation and Configuration

Overview

- Workflow is provided to perform configuration of zOSCP:
  - /usr/lpp/IBM/zoscp/workflows/zoscp_general.xml
- Documentation references workflow – it is expected that the end user go through the workflow for configuration.
- Workflow is scoped at a system level and should be performed on each system where zOSCP is to be configured.
- Some steps are manual and require updates to be made to parmlib or submit a security sample job.
- Expectation is the workflow is run by a uid=0 user or one that has access to BPX.SUPERUSER.

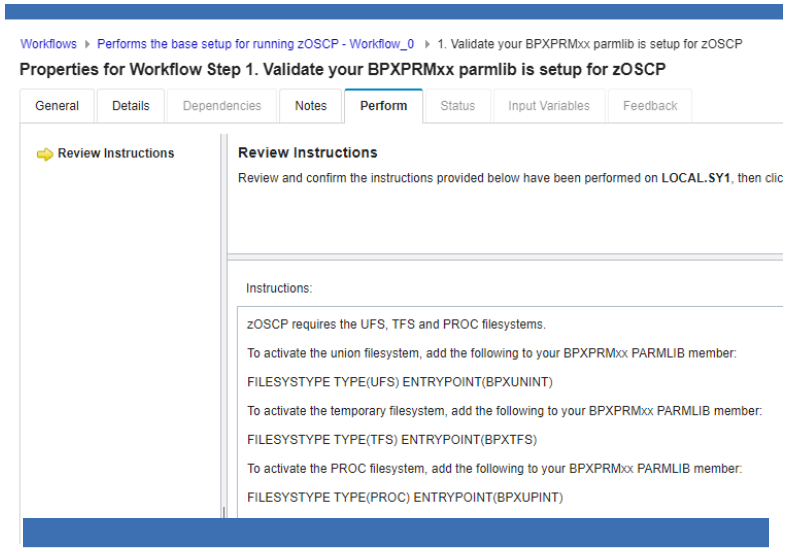
z/OSMF Workflow

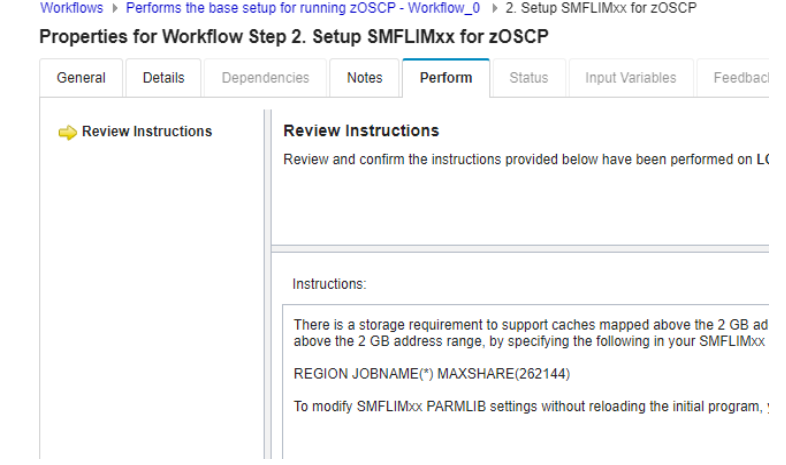
- Steps are expected to be completed in order, with some steps disabled until prior steps are completed.
- Some steps use inline JCL, while others call a shell script with BPXBATCH



Parmlib Changes (steps 1-2)

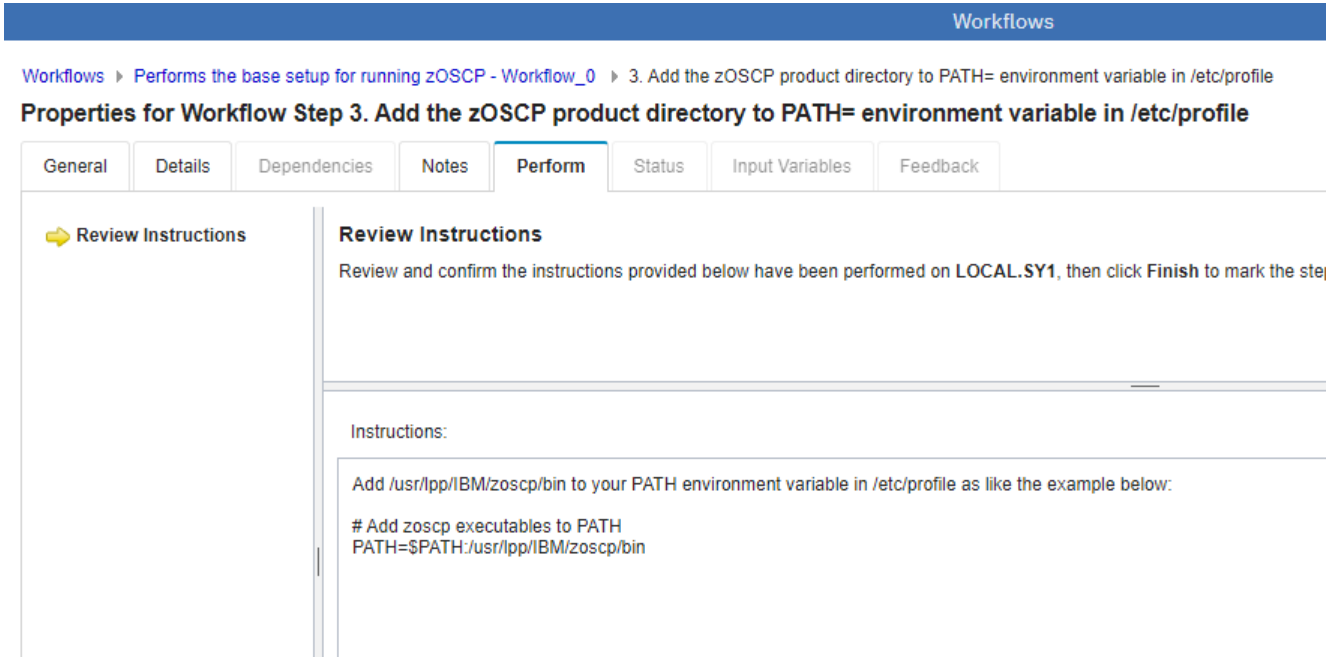
- zOSCP requires UFS, TFS, and PROC filesystems set in BPXPRMxx
- /proc needs to exist before PROC can be mounted
- SMFLIMxx needs to be updated to support caches mapped about the 2GB address range





PATH update (step 3)

- The /usr/lpp/IBM/zoscp/bin should be added to the PATH environment variable in /etc/profile



Security Setup (step 4)

- This step points to the sample job SYS1.SBCZSMPL(BCZSECS1) which needs to be reviewed, modified and run by a z/OS Security Administrator.
- The security job creates a PODMAN group and gives it access to the CONTAINERS SAF resource in the UNIXPRIV class.
- This gives non-UID 0 users access to run containers on z/OS with tools like podman.

```
/* Create group that will be given access to run podman            */
/* ADDGROUP PODMAN OMVS(AUTOGID)                                   */
/* RDEFINE UNIXPRIV CONTAINERS UACC(NONE)                          */
/* PERMIT CONTAINERS ID(PODMAN) ACCESS(READ) CLASS(UNIXPRIV)       */
/* SETROPTS RACLIST(UNIXPRIV) REFRESH                              */

/* To connect a user ID to the PODMAN group, run:                  */
/* CONNECT <userid> GROUP(PODMAN)                                  */
/* Where the <userid> is the user ID you want to connect to the    */
/* PODMAN group.                                                   */
```

Filesystem Setup (steps 5,6,7)

- These automated steps setup both permanent and temporary filesystems used by podman:
  - /var/lib/podman : permanent filesystem used by an administrator to store images for other users of podman
  - /var/run/containers : tfs used for container metadata for uid=0
  - /var/run/runc : tfs used by runc for uid=0
  - /var/run/user : tfs where user specific metadata is stored
- After /var/lib/podman is setup, a bind mount is used to share /var/lib/podman/storage read-only with unprivileged users. The bind mount is created at /var/share/containers/storage.
- /var/share/containers/storage is the default additional image store for unprivileged users on z/OS.

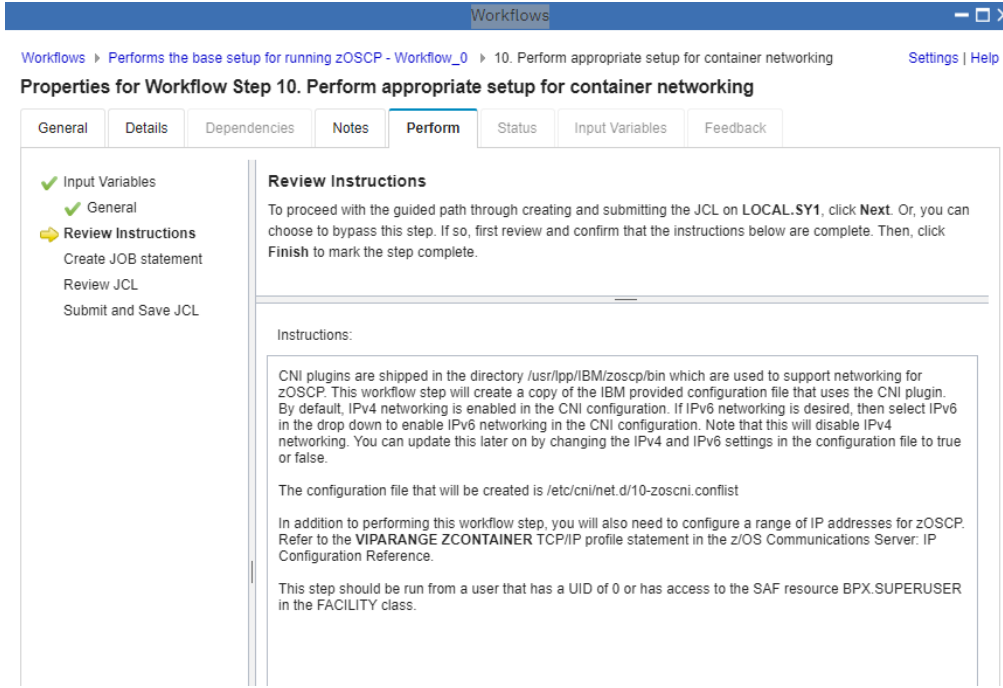
Configuration Files (step 8)

- This step copies default container configuration files to the appropriate location on the system:
  - containers.conf : default configuration options for podman
  - mounts.conf : default mounts for podman
  - registries.conf : container registry configuration
  - storage.conf : container storage options
  - policy.json : specifies policy for accepting images. Note that the default we provide rejects images from all registries. The podman trust command can be used to trust a registry, which will update this file and allow images to be pulled from that location.

- If these files already have been copied, no copy is done.

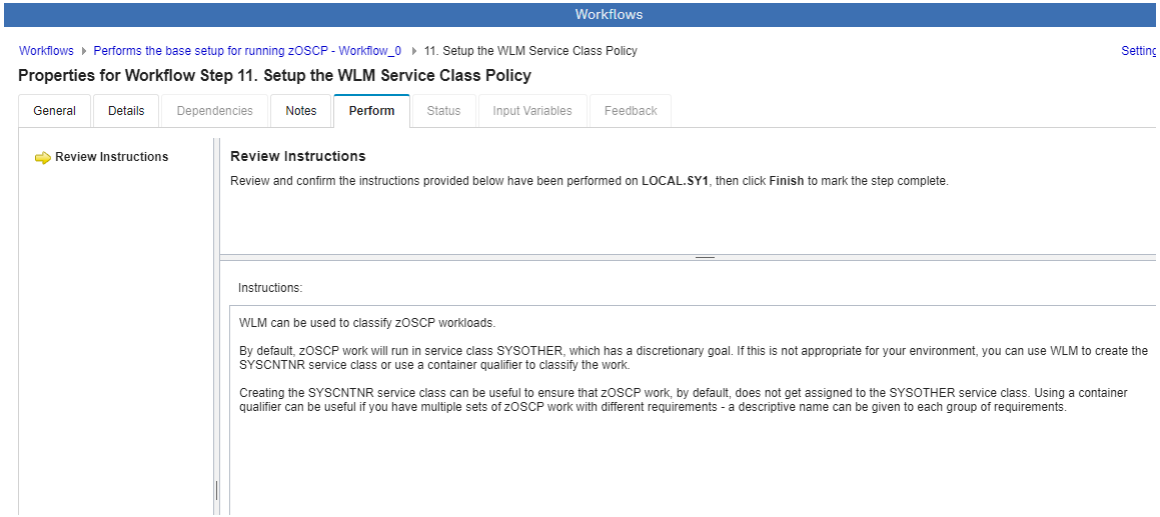
Networking Setup (step 9,10)

- These steps go over the configuration updates required to support container networking on zOSCP.
- VIPARANGE ZCONTAINER IP address ranges need to be setup manually in the TCP/IP profile statement.



WLM Configuration (step 11)

- This is a manual step that provides instructions on how WLM can be used to classify zOSCP workloads.
- The SYSCNTNR service class or a container qualifier can be used to classify the work.



Installation Verification (step 12)

- The final step of the workflow runs an installation verification program (shell script)
- The program does the following checks:
  - Checks to make sure all necessary filesystems are mounted and enabled (UFS, TFS, PROC)
  - Checks to make sure install directories exist (/usr/lpp/IBM/zoscp/bin)
  - Ensures LE has been setup appropriately to run containers
  - Builds and runs a podman “hello world” rexx image
- This program can also be run in the shell outside of the workflow.

Images and Image Management

Overview

- Problem Statement / Need Addressed / User Stories:
  - Customers need a “base” environment in their containers
  - z/OS Container Platform target image infrastructure requires special authority
- Solution:
  - IBM provides a “base” image to customers through IBM Cloud Container Registry
- Benefit / Value:
  - Use of “base” image and icr.io is existing/familiar and aids build/debug
  - z/OS administrator continues to control security characteristics of system

Image architecture and operating system

- Every OCI image has an architecture and os

```
$ skopeo inspect --config docker://icr.io/zos
{
    "created": "2024-02-15T22:57:27.624488767Z",
    "architecture": "s390x",
    "os": "zos",
```

- z/OS Container Platform uses **zos** on **s390x** images, *not linux images*
- Prior to z/OS Container Platform, such images did not exist

Image Locations

Image name	Location	Description
zos	icr.io/zoscp/zos:latest	Foundation image, consisting of a basic z/OS UNIX environment with core z/OS programs and libraries.
ibmjava	icr.io/zoscp/ibmjava:8	Builds on the z/OS base image to provide IBM SDK for z/OS, Java Technology Edition, Version 8 - 64-bit version and source code for the sample Java application.
ibm-zcon-server	icr.io/zosconnectunlimited/ibm-zcon-server:3.0.78	Builds on z/OS base and Java images to enable building a z/OS Connect application.
golang	icr.io/zoscp/golang:latest	Go (golang) is a general purpose, higher-level, imperative programming language.

location, key, and sample command provided in associated product memo

zOSCP z/OS Control Plane Appliance (zCPA)

Overview

- Problem Statement:

  Need to provide control plane node for z/OS-based Kubernetes cluster

- Solution:

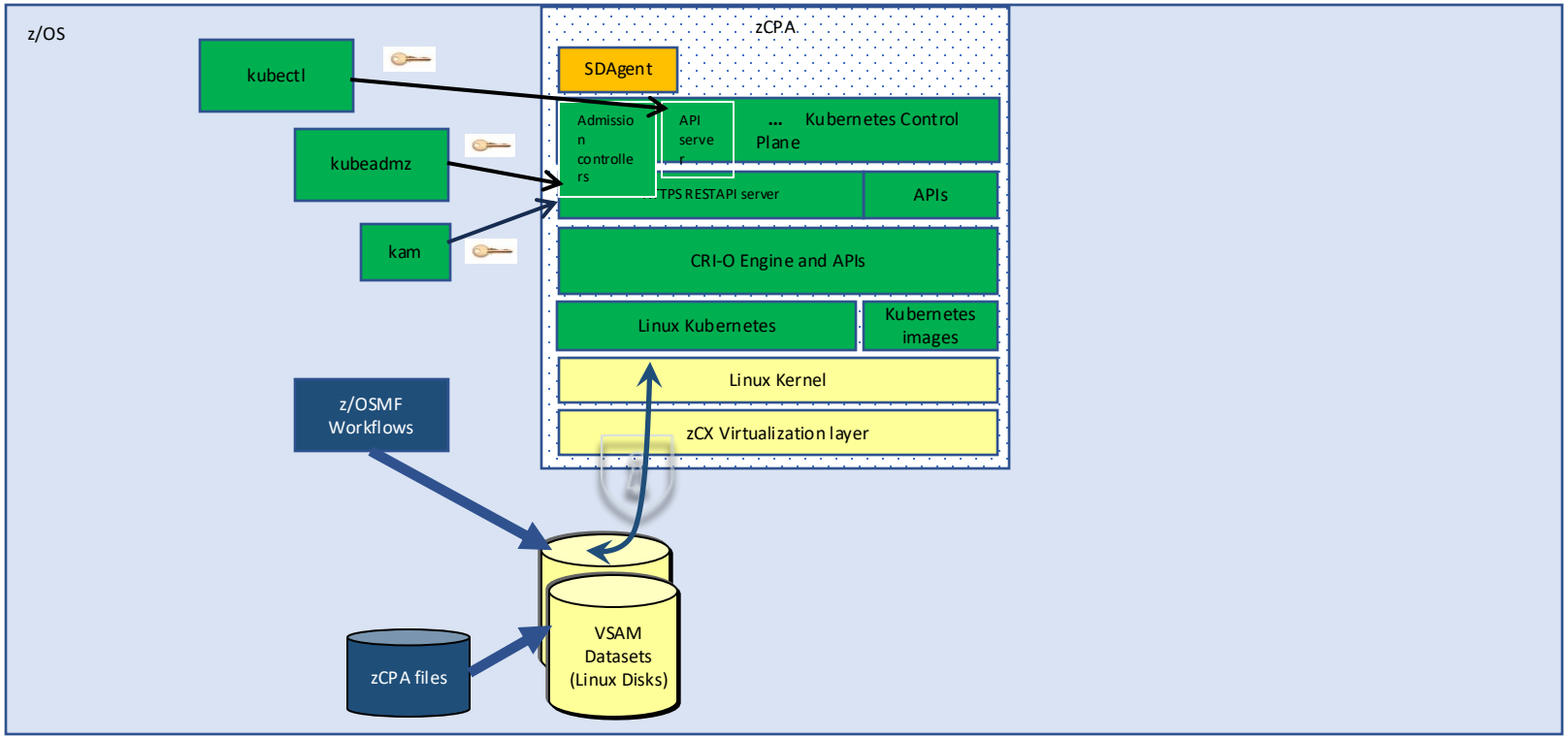
  Create Linux-based appliance that runs within z/OS address space that can host the control plane node infrastructure

- Benefit / Value:

  Ensure all Kubernetes cluster nodes for zOSCP reside on z/OS systems

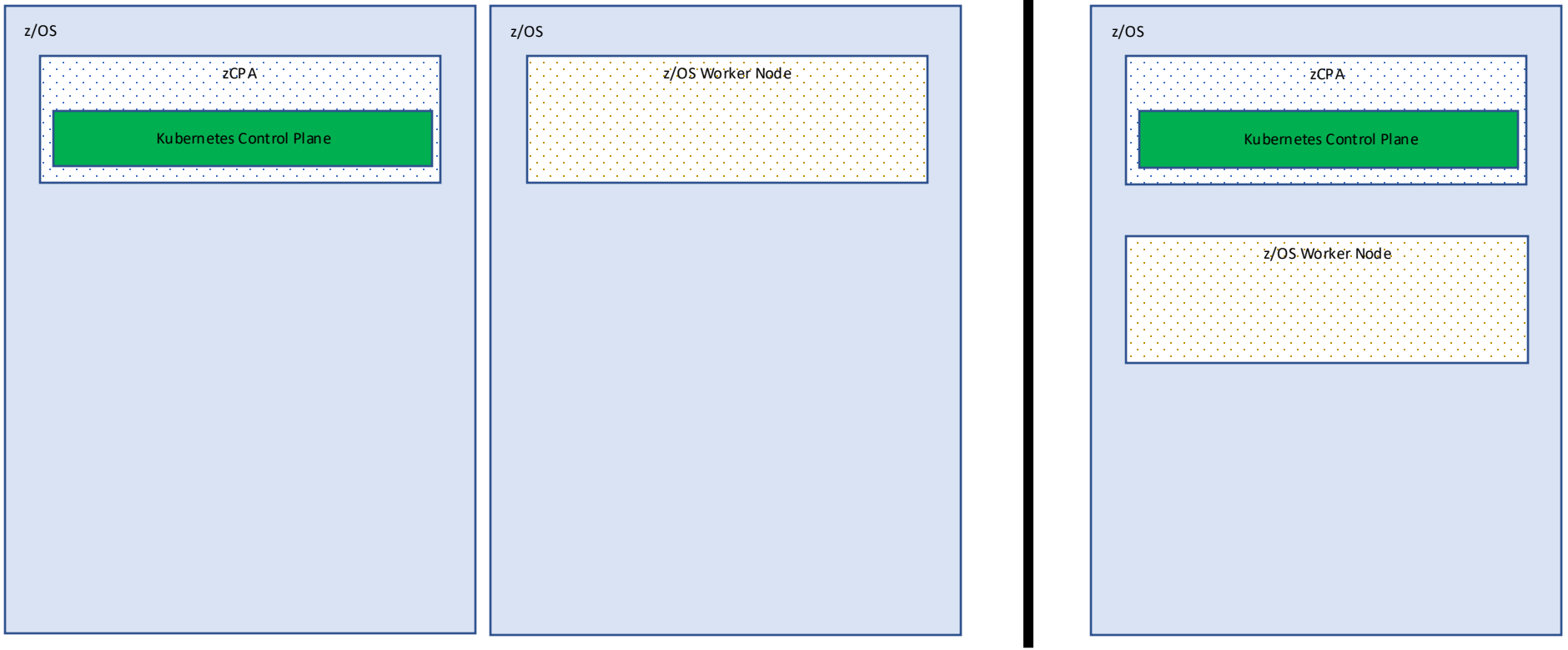
Solution

Create Linux-based appliance that serves as a control plane node



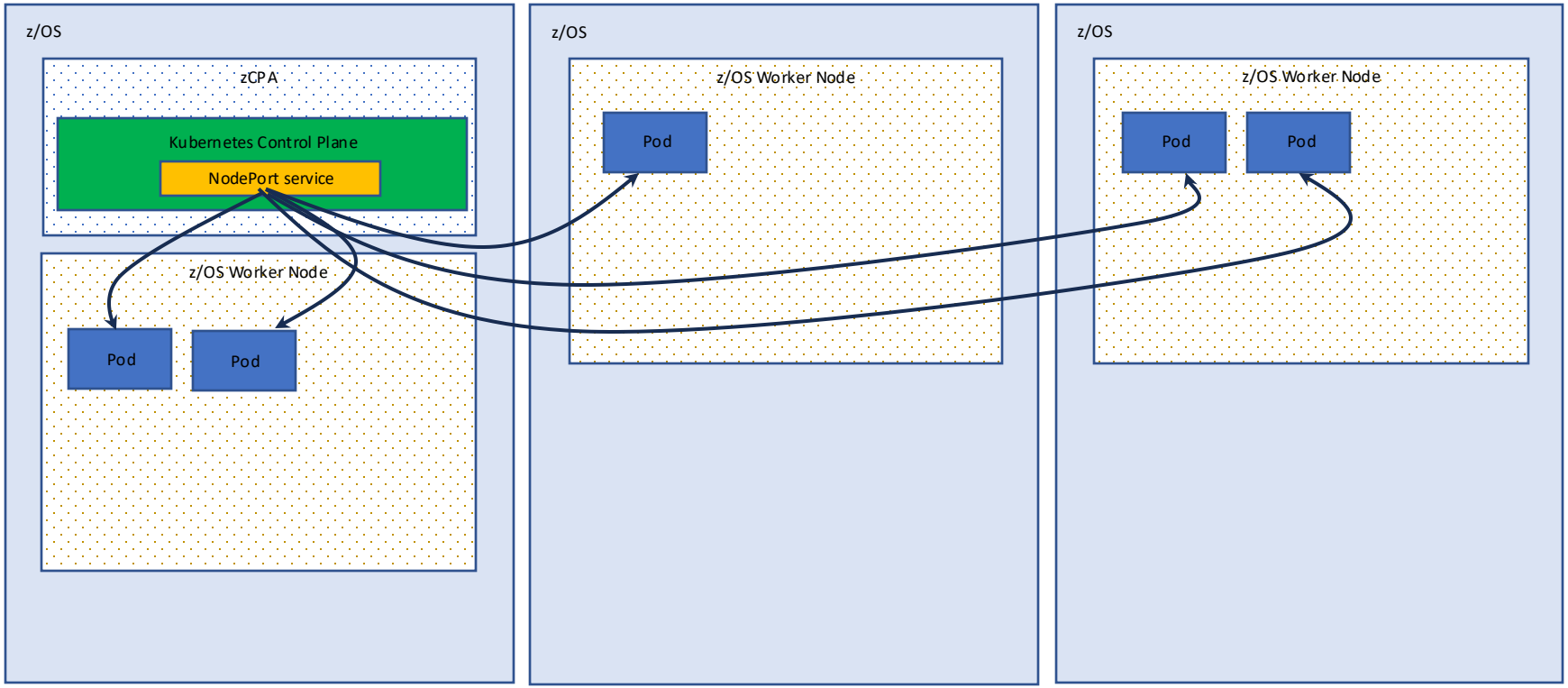
Solution…

Possible configurations



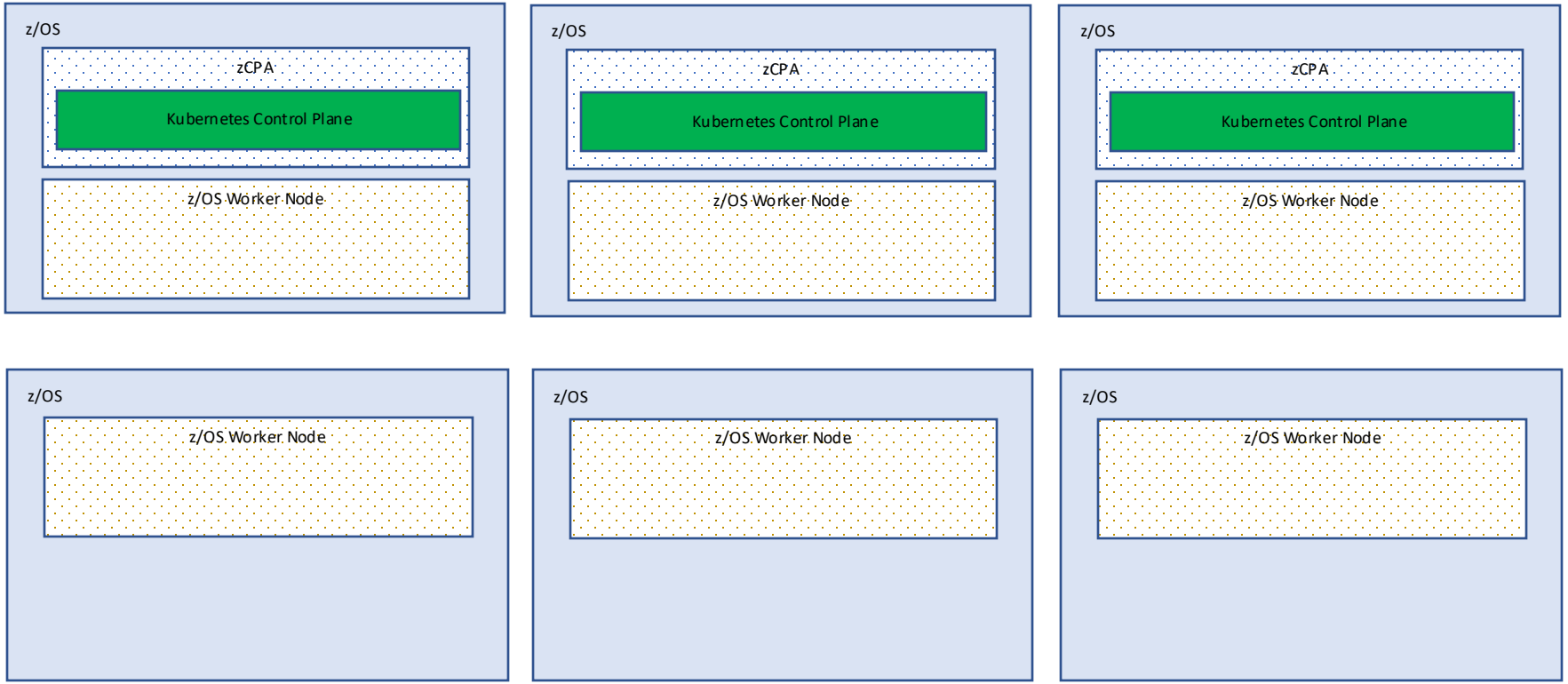
Solution…

NodePort load balancing



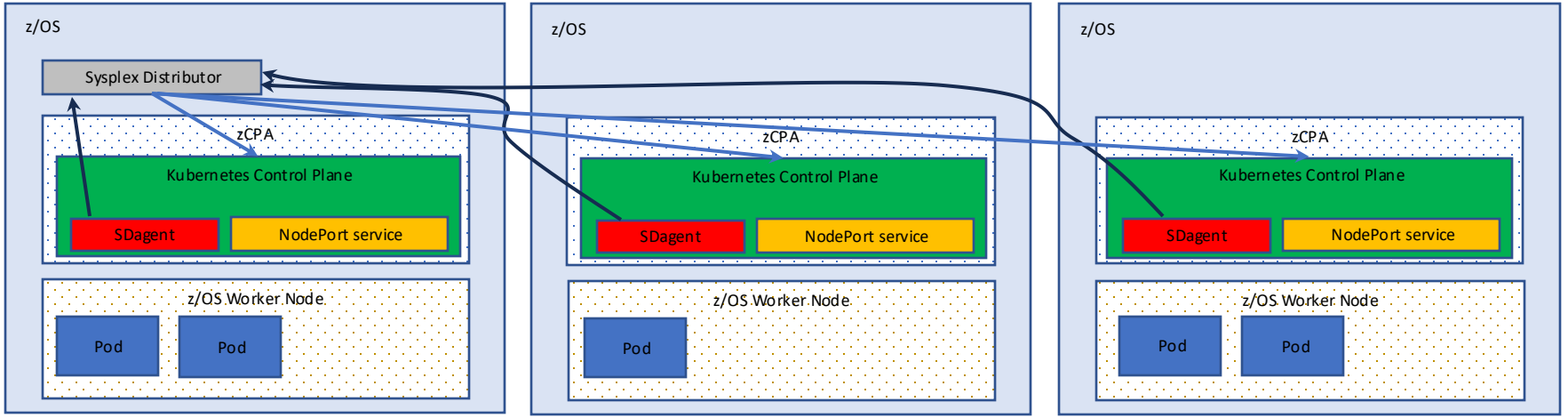
Solution…

High Availability configuration



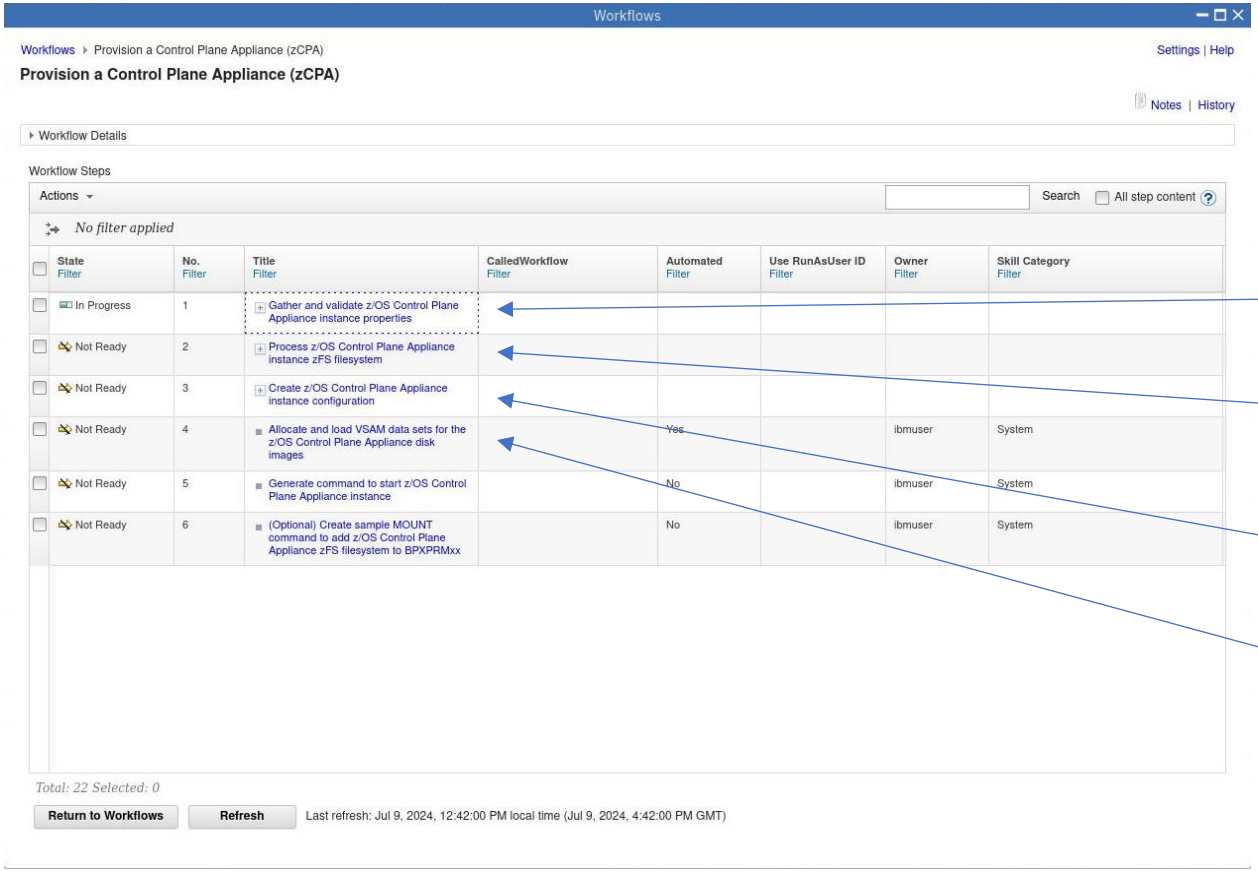
Benefits

Leverage Sysplex Distributor for High Availability load balancing



zCPA workflows

zCPA Provisioning workflow



Main Provisioning Steps

Gather configuration information for zCPA being provisioned

- Determines latest installed version

Allocate and mount zCPA-specific zFS

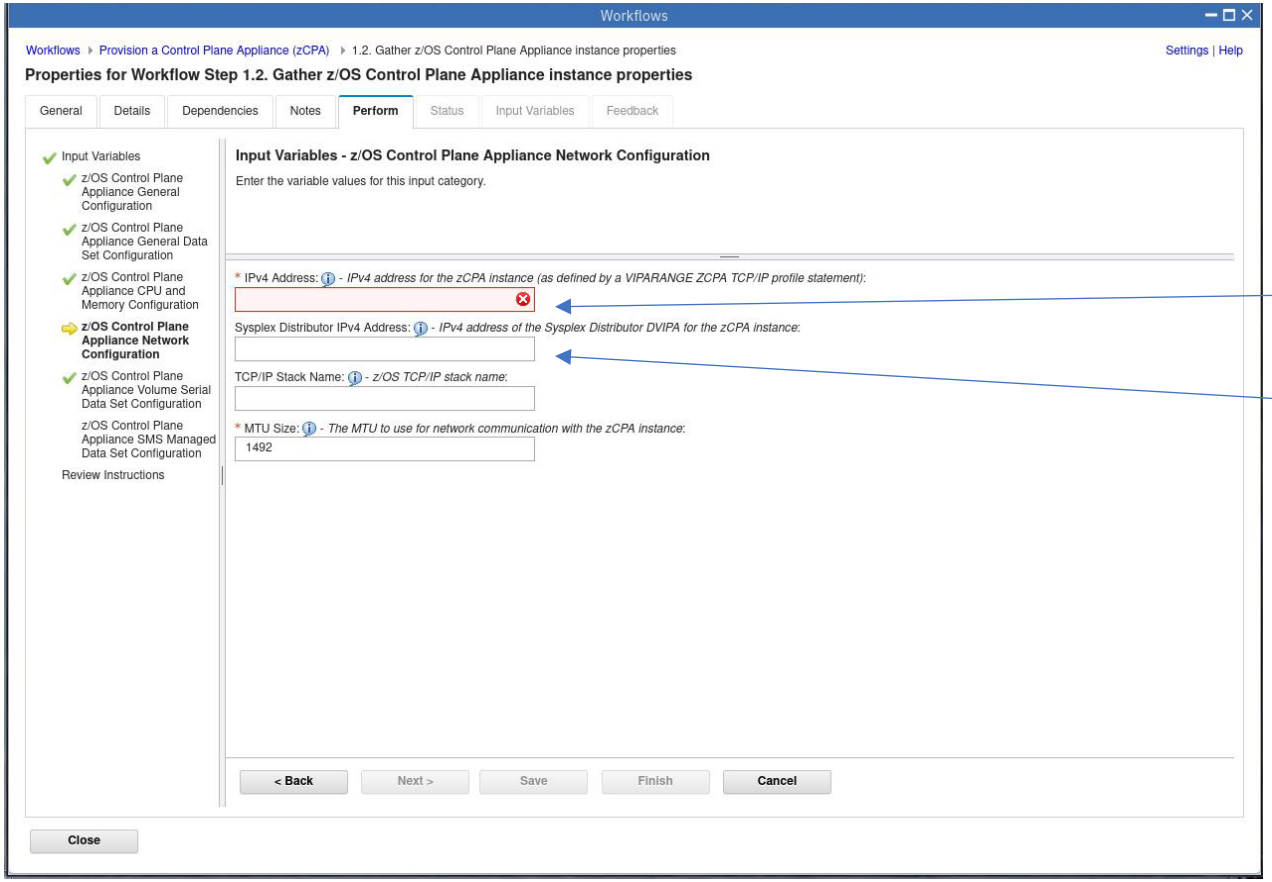
- Holds configuration files and cached input for subsequent workflows

Create configuration files for zCPA being provisioned

Allocate and build VSAM datasets from provided zCPA image files

- Serves as Linux filesystems for zCPA

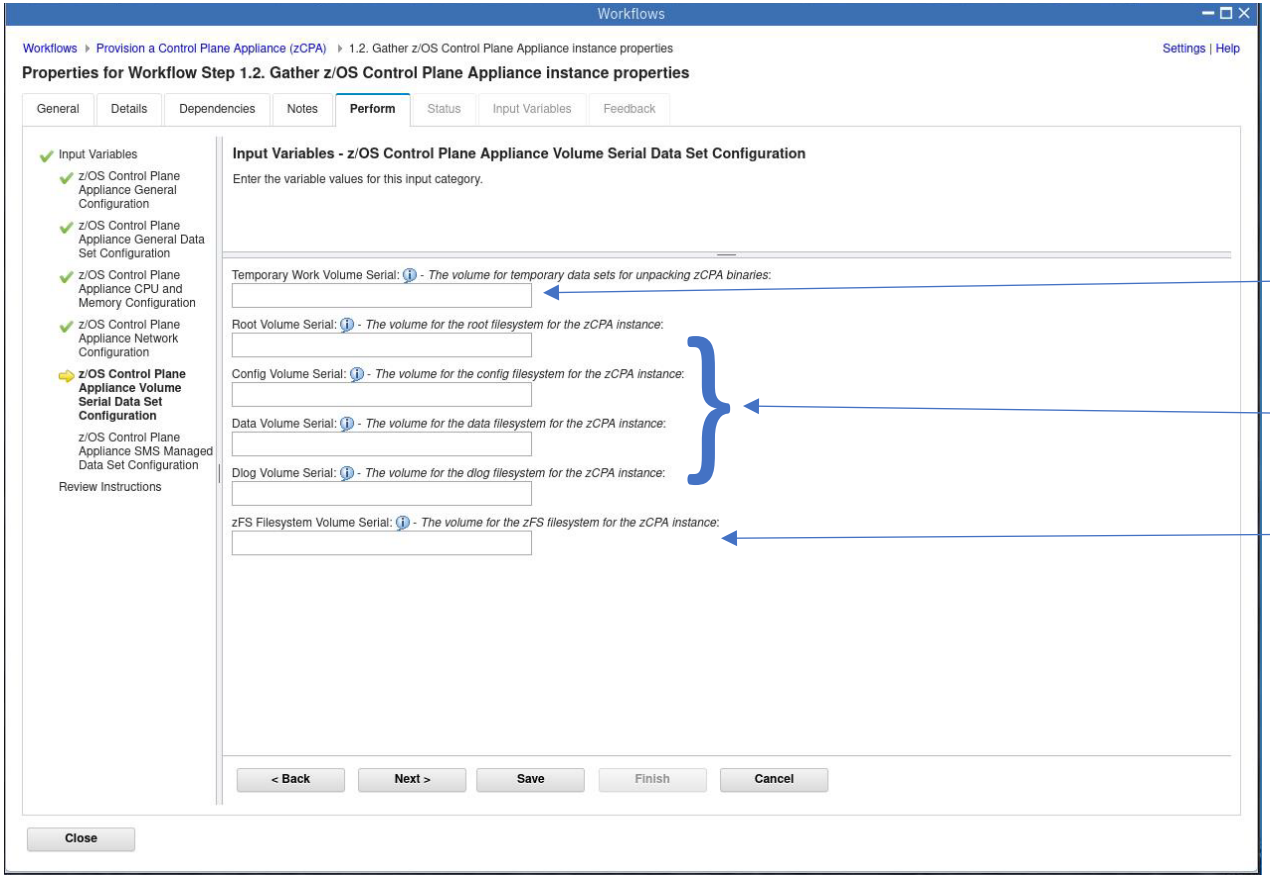
zCPA Provisioning workflow – network configuration



IPv4 dynamic VIPA assigned from VIPARANGE ZCPA statement in the TCP/IP profile

IPv4 distributable dynamic VIPA assigned from VIPADISTRIBUTE EXTTARG statement in TCP/IP profile

zCPA Provisioning workflow – filesystem configuration



Temporary volume to recombine and uncompress zCPA filesystems

Volume(s) to store VSAM files representing the zCPA mounted filesystems

Volume to allocate zFS for the zCPA instance

- Needs to be large enough to hold any zCPA dumps along with configuration files

SMS-managed storage can be used

Starting the zCPA

```
GLZB025I zCX instance ZCPA1: Initialization has started. Code date 06/14/24.
:
EZD1204I DYNAMIC VIPA 9.67.170.243 WAS CREATED USING IOCTL BY ZCPA1 ON TCPIP
EZD0009I CONNECTION TO 9.67.170.243 ACTIVE FOR INTERFACE EZAZCX
:
GLZB022I zCX instance ZCPA1 version information
Bootloader:           HZDC7C0             oa66001
                      3.7.3               2.4.0
Current Appliance:    HCZ1110             OA66262
                      4.4.3               1.29.5
                      20240630T205536Z
Available Appliance:  HCZ1110             OA66262
                      4.4.3               1.29.5
                      20240630T205536Z
Virtualization Layer: HBB77D0   UJ95425   06/14/24
                      Started on 2024/07/02 10:53:25
Workflows Performed:
Provision:            1.0.1     HCZ1110   2024/07/01 16:35
Reconfigure:          N/A       N/A       N/A
Upgrade:              N/A       N/A       N/A
Add Data Disks:       N/A       N/A       N/A
:
GLZB027I zCX instance ZCPA1: IPLing guest.
GLZM012I zCX services for instance ZCPA1 are available.
```

Dynamic VIPA created from VIPARANGE ZCPA TCP/IP profile statement

APAR level and version of the zCPA instance

Latest installed APAR level and version for the zCPA

Only provisioning workflow has been performed on the zCPA instance

zCPA is now ready to start control plane node

Thank you

Redelf Janßen

Contact

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