# Multi-architecture devOps using OpenShift

In this lab you will learn how to deploy a Jenkins pipeline to build your source code from github and deploy it to both OpenShift on Intel and OpenShift on IBM Z/LinuxONE. While there are several other steps in a devOps process, we will only focus on the deployment aspect here.



---

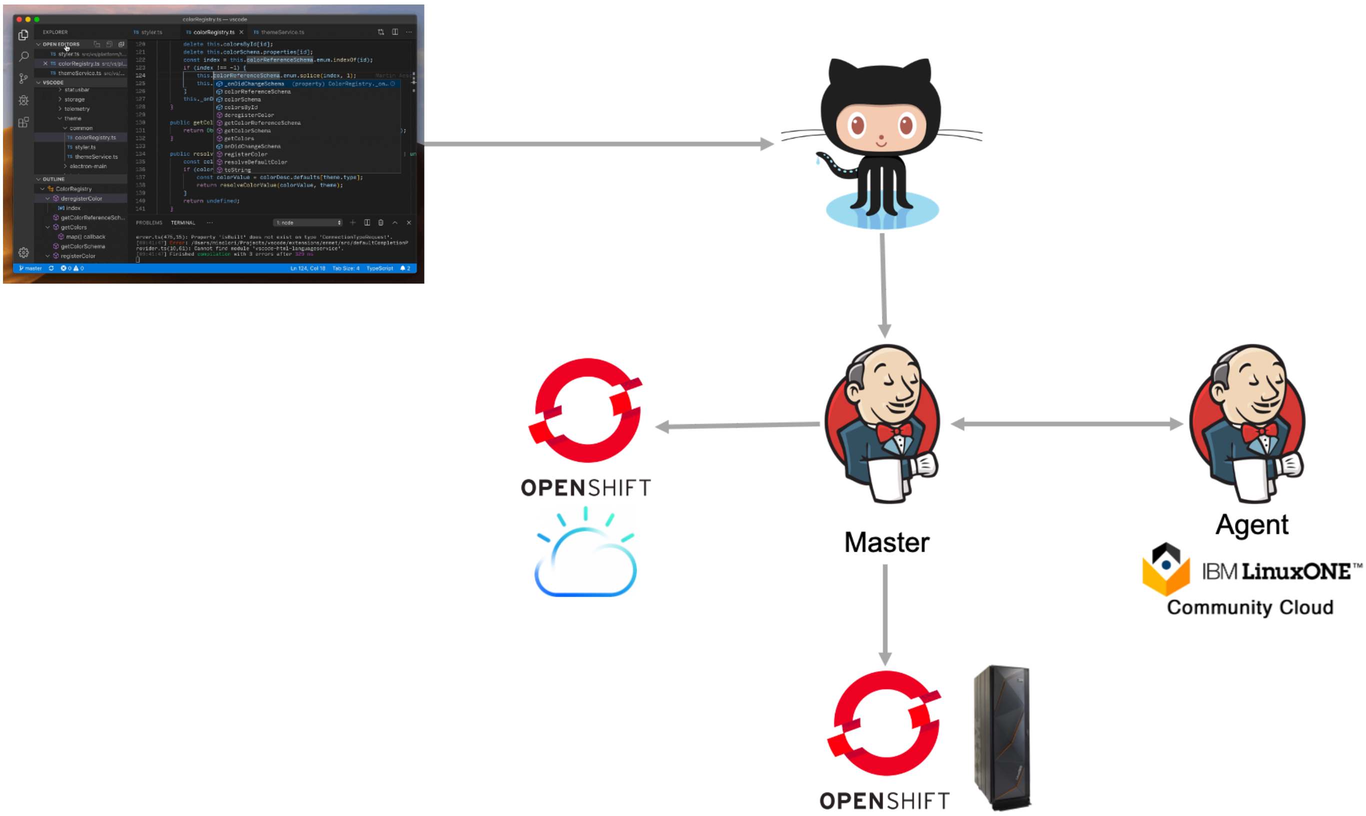
## ID Prerequisites

- GitHub
- Docker and Docker Access Token
- IBM Cloud
- IBM Washington System Center (will be distributed as part of the lab)
- LinuxONE Community Cloud (optional, but useful for self paced lab)

## Environment

- RedHat OpenShift (ROKS) on IBM Cloud
- RedHat OpenShift on IBM LinuxONE (in IBM Washington System Center)
- Jenkins (in IBM Washington System Center)
- IBM Container Registry on IBM Cloud
- Jenkins agent on IBM LinuxONE Community Cloud

## Topology Diagram




> **Note:** Using the Kubernetes Jenkins plugin or OCP native Jenkins or other cloud native devOps pipeline tooling would enable even fewer moving parts.

You can run the Jenkins master itself on one of the clusters and the agent in another OCP cluster, reducing the need for 2 separate VMs. It will be much easier to manage/scale and Jenkins kubernetes plugin can even create ephemeral agents just to build and then destroy if needed. As you will note in the Jenkins section below, the goal of this lab is to go through each step as a learning exercise and to stay away from opinionated CI/CD tooling.

**LinuxONE Community Cloud**

TODO : More on L1CC

## What is a multi-architecture deployment anyway?

A multi-architecture deployment is a deployment that lets you consume the same image (e.g hello-world:latest) on any platform using the same deployment artifacts (pod definitions, deployments, services, routes etc). This greatly simplifies the deployment process while letting an organization optimize for metrics like:

- Cost
- Throughput
- Latency
- Security and Compliance
- Scalability
- Resiliency and reliability
- Uptime

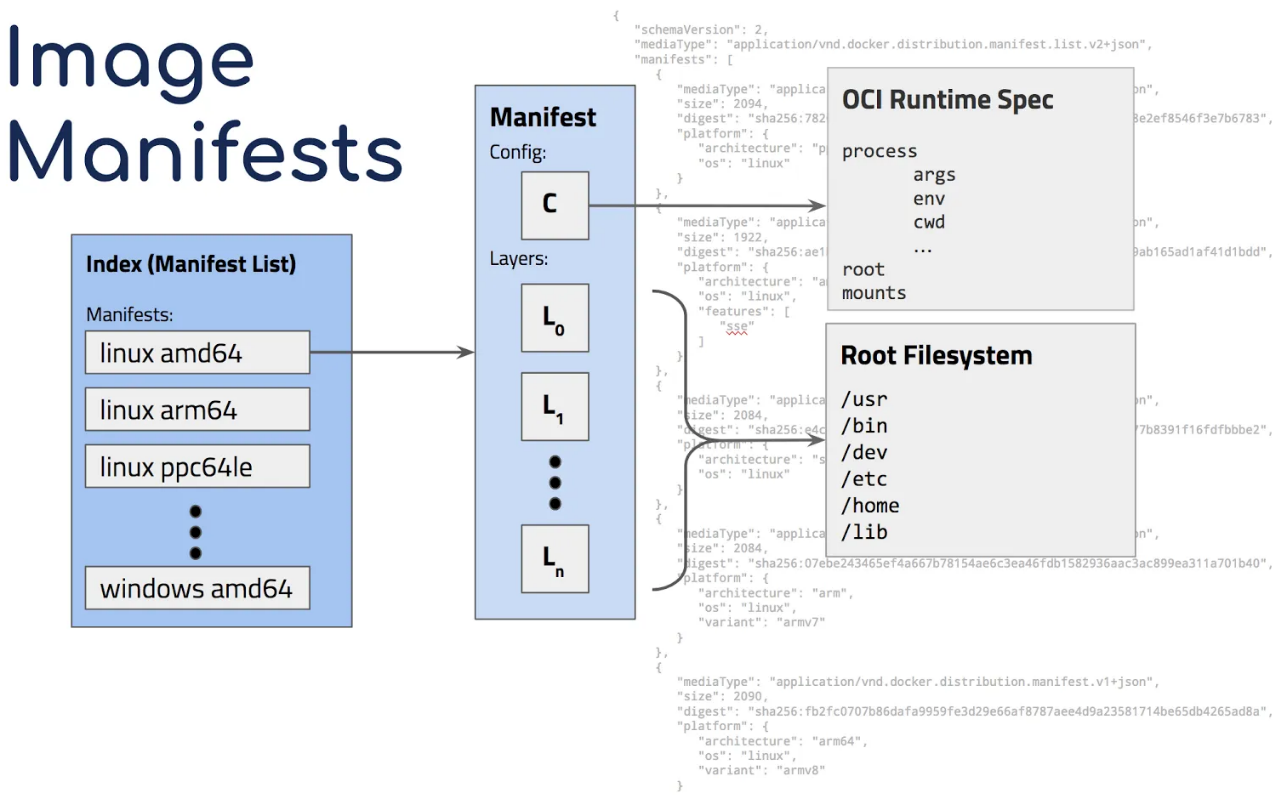
Platforms include:

- Operating System (windows, linux etc)
- Instruction Architecture (**amd64**, **s390x**, ppcle64, arm, arm64 etc)

### Dockerfile

Writing a simple Dockerfile is easy, but we thought including some best practices here will help, esp since it will help speed up the multi-arch build process.

### Multi-architecture Manifests



To enable multi-architecture, docker added support for manifests which let you link which platform to image (but exposing the end result as the same image). e.g "docker run hello-world" will first look at the version (`latest` is implied if no version tag is specified) then will check the local operating system and architecture (e.g linux, s390x) and query that combination in the registry. Once it fins that combination, it'll pull *only that specific container* locally. Multi-arch images are similar to "fat binaries" at the container registry level but single, os and architecture specific images at the docker daemon level.

By default the Docker daemon will look at its current operating system and architecture but it is possible to force download of a specific platform/architecture using the `--platform` command which is available in docker API 1.32+ and need `experimental features` turned on in Docker daemon. The full specification of multi-architecture manifests can be found here. More information on `docker pull` be found in the official docs here.

### Building multi-arch images

Images are just binaries and as such, require to be built on the appropriate platform (build architecture = destination architecture). There are 2 ways of building multi-arch images:

- docker buildx builder
- docker default builder

The buildx builder is the most convenient mechanism but can be very slow for non-native architectures as it is emulating the target architectures ISA in qemu. Docker's default builder is the most popular and is used in production by almost every organization building multi-arch images, but needs to run on the destination architecture while building.

### Combining multi-arch images and manifests

The first step is to build the containers on each architecture and store then in a single location. You could push them separately once the manifest is pushed to the repo.

We build these images with these specific tags as it'll make mapping architectures to containers easier.

```
thinklab/go-hello-world:amd64-latest
thinklab/go-hello-world:arm32-latest
thinklab/go-hello-world:s390x-latest
```

> **Note, you must push the containers to your container registry *before* creating a manifest. Having them in your local registry isn't enough**

Next, we create a manifest which contains each of these images:

```
docker manifest create thinklab/go-hello-world:latest \
thinklab/go-hello-world:amd64-latest \
thinklab/go-hello-world:arm32-latest \
thinklab/go-hello-world:s390x-latest
```

Now let's review the output of:

```
docker manifest inspect thinklab/go-hello-world:latest
```


```
{
  "schemaVersion": 2,
  "mediaType":
"application/vnd.docker.distribution.manifest.list.v2+json",
  "manifests": [
    {
      "mediaType": "application/vnd.docker.distribution.manifest.v2+json",
      "size": 3254,
      "digest": "sha256:....",
      "platform": {
        "architecture": "s390x",
        "os": "linux"
      }
    },
    {
      "mediaType": "application/vnd.docker.distribution.manifest.v2+json",
      "size": 3038,
      "digest": "sha256:....",
      "platform": {
        "architecture": "arm",
        "os": "linux"
      }
    },
    {
      "mediaType": "application/vnd.docker.distribution.manifest.v2+json",
      "size": 2824,
      "digest": "sha256:....",
      "platform": {
        "architecture": "amd64",
        "os": "linux"
      }
    }
  ]
}
```


The manifest command automatically picked up and annotated the architecture and operating system for each image.

You could also manually annotate with:

```
docker manifest annotate thinklab/go-hello-world:latest \
thinklab/go-hello-world:s390x-latest --arch s390x --os linux
```

If we want to update the images referenced in the manifest, we could rebuild and tag appropriately, then run:

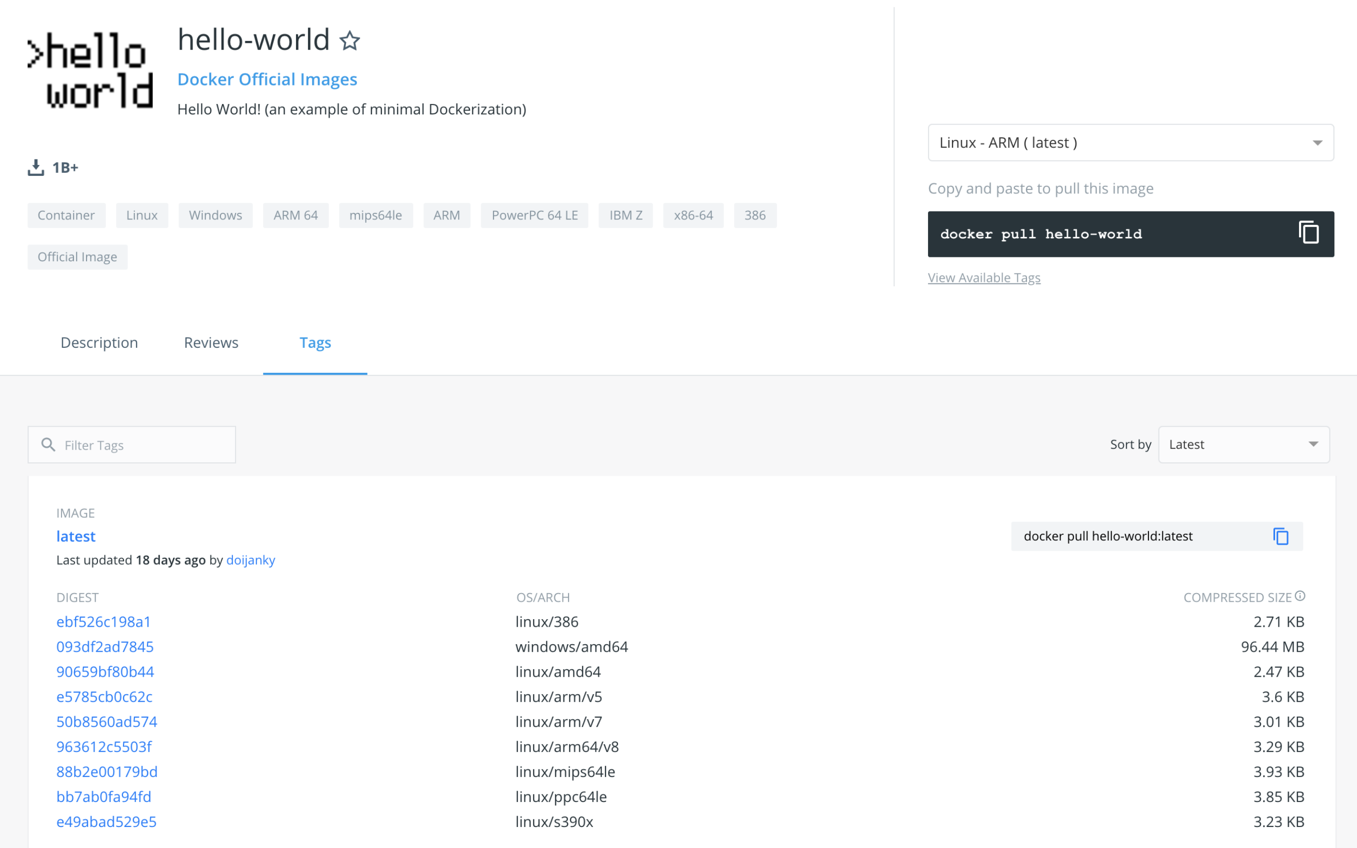
```
docker manifest create thinklab/go-hello-world:latest \
--amend thinklab/go-hello-world:amd64-latest \
```

```
docker manifest push thinklab/go-hello-world:latest
```

Now you can do a docker pull on either Intel, ARM or IBM Z (s390x) and it will automatically pull the right container. This also applies to Kubernetes since internally, a pod just pulls the container following OCI spec.

```
docker pull thinklab/go-hello-world
```

This is just a small sample of platform options. If you look at the `hello-world` container, you'll several 9 different combinations of architecture and platform.




## Container Registries

When doing multi-arch, not all container registries are created equal. There are a few factors that might be important to help make a selection.

| Name | Supports multi-architecture manifests | Certified for LinuxONE | Independent Product |
|---|---|---|---|

| Name | Supports multi-architecture manifests | Certified for LinuxONE | Independent Product |
|---|---|---|---|
| OpenShift Container Registry | ✅ | ✅ | |
| Quay | ✅ | | ✅ |
| Docker Trusted Registry | ✅ | ✅ | |
| jFrog Artifactory | ✅ | | ✅ |
| Gitlab | ✅ | | ✅ |

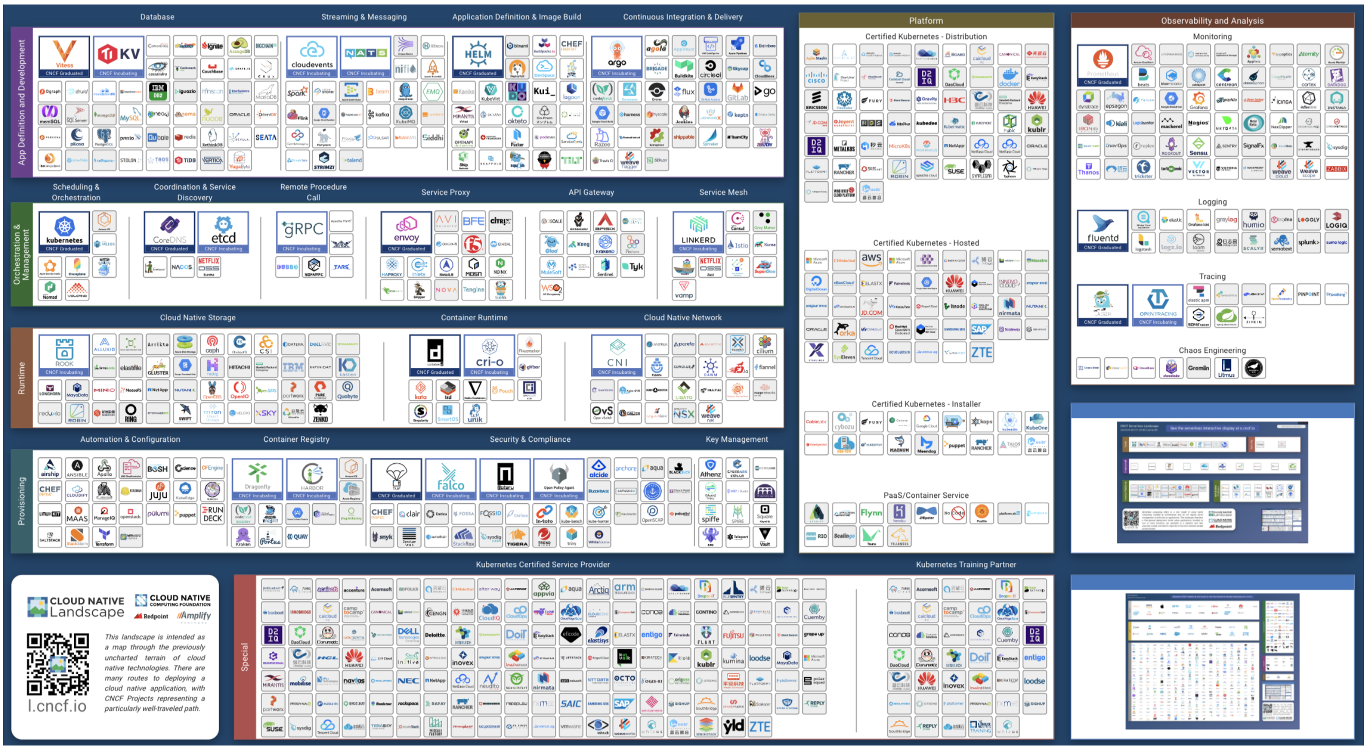
*Supports multi-architecture manifests:* Not all registries support multi-arch manifests, the ones in the list do as they are relatively mature projects, but there are several in the wild that do not.

*Certified for LinuxONE:* A registry might be able to store images tagged for the `s390x` architecture but the registry itself might not run on a LinuxONE server. This is important as several organizations prefer to run their mission critical workloads and databases on LinuxONE and since a container registry stores images used in production, LinuxONE support is favorable.

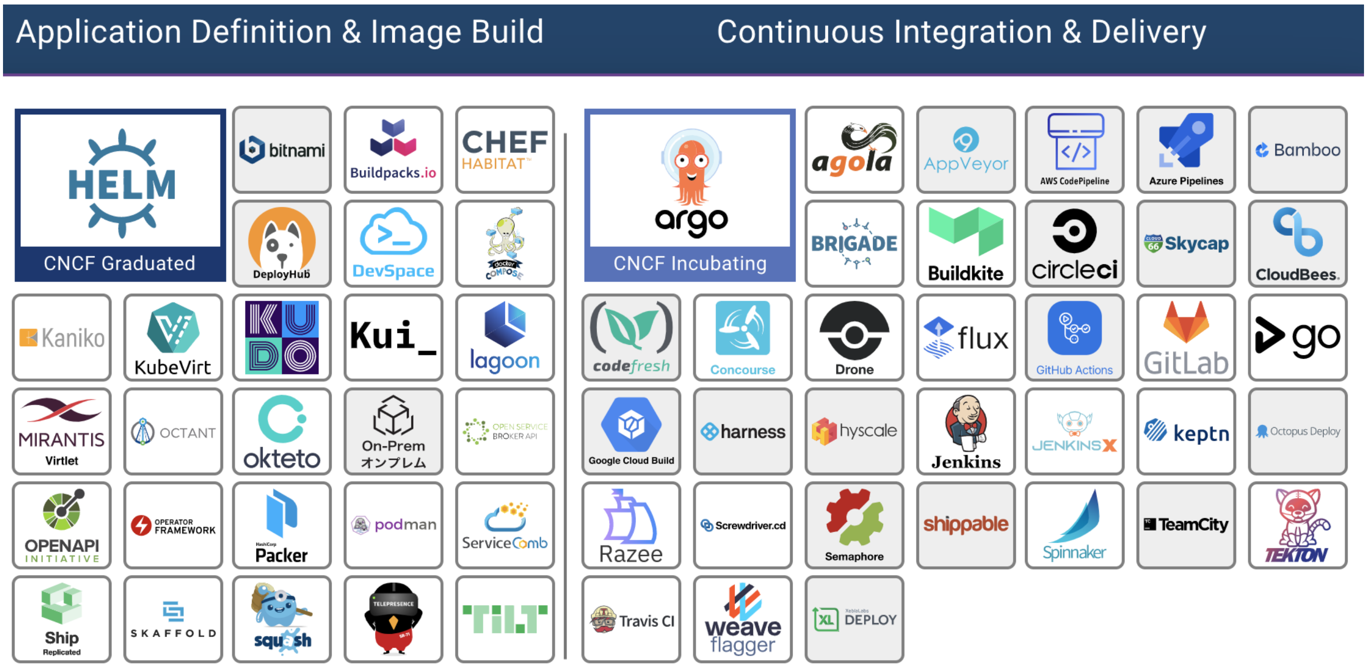
*Independent Product:* A registry might come bundled with a larger set of products. Independent Product implies it can run on its own, without an overarching product.

## DevOps ecosystem

This is a map of the CNCF ecosystem around containers:



Drill down to the build and delivery section:




As there are many options, each doing things in its own opinionated way, we will use Jenkins for this lab which will give you a foundation to build upon and consume the other tools.

Jenkins

We will not cover Jenkins setup as it is a "household name" in the world of modern delivery pipelines. More information can be found at Jenkins official

*Useful plugins to install:*

- SSH
- Kubernetes
- OpenShift Jenkins Pipeline
- OpenShift Login

> **Note:** While using Jenkins plugins will make this *much* easier, we will do ***deployments the hard way*** as a learning exercise in this lab. We will just be using Jenkins as a glorified remote bash scripts runner, so every step is clear.

Other tools such as Tekton, JenkinsX, Razee etc make this much easier as they were built for kubernetes CI/CD. Cloud providers offer their own build tooling and now even GitHub offers native CI/CD with GitHub Actions. You will most likely use these other tools in production environments.

#### Nodes

If you don't specify a node, Jenkins will run the stage on any node. If you only use one architecture the default behavior might be ok but for multi-arch builds, you need to build on the deployment architecture if you use the native docker builder (`docker build`). Note, the `s390x` here is a label you must explicitly give your Jenkins nodes. You can call the node what ever you want but having the architecture in its name will help for this lab. *Jenkins has no innate architectural recognition capability.*

```
node ('s390x') {
    stage('Source') {
        // Get some code from our Git repository
        git 'https://github.com/IBM/node-s2i-openshift.git'
    }
    stage('Build') {
        // Build the container
        docker build -t node .
    }
    ..
}
```

Mixed node pipelines are also possible:

```
node ('s390x') {
    ..
}
node {
    ..
}
node ('prod') {
    ..
}
```

Here, the stages in the middle `node {}` can run on any node, the stages on the `node ('prod')` will run on any nodes with prod label and of course, `node ('s390x')` will run on our node labeled s390x for this lab.

## Application

We will be using a simple hello-world Go web-server, that provides some interactivity in terms of its output across code changes. We will be using a Go app that prints `Hello, World!` on http://localhost:8080 . This will also be a good test for Routing in OpenShift. The simplest way to deploy an app to OpenShift if you have a container in a cluster accessible repo, is to use `oc new-app [container name]`

So in our lab, it will be:

`oc new-app thinklab/go-hello-world`

You should see an output similar to this:

```
--> Found container image 90bd6b5 (32 minutes old) from Docker Hub for
"thinklab/go-hello-world"

    * An image stream tag will be created as "go-hello-world:latest" that
will track this image
    * This image will be deployed in deployment config "go-hello-world"
    * The image does not expose any ports - if you want to load balance or
send traffic to this component
      you will need to create a service with 'oc expose dc/go-hello-world
--port=[port]' later

--> Creating resources ...
    imagestreamtag.image.openshift.io "go-hello-world:latest" created
    deploymentconfig.apps.openshift.io "go-hello-world" created
--> Success
    Run 'oc status' to view your app.
```

`oc status` will show:

```
In project team00 on server https://api.atsocpd1.dmz:6443

http://go-hello-world-team00.apps.atsocpd1.dmz to pod port 8080-tcp
(svc/go-hello-world)
...
```

Next, to map it to localhost, you could: `oc get pods`

```
NAME                                  READY    STATUS       RESTARTS    AGE
go-hello-world-84s76                1/1      Running     0           55s
..
```

and then

```
kubectl port-forward go-hello-world-84s76 8090:8080
```

Then either moving this to the background or opening a new session,

`curl localhost:8080`

which will show:

```
Hello, World!
```

## Putting it all together

Putting the build and deploy steps together:

1. Fork the code into your GitHub repo
2. Modify the Jenkinsfile and replace *["GIT REPO HERE"]* to use your repo
3. Copy the contents of the Jenkinsfile to your Jenkins job
4. Run the job
5. See your output at https://ip:port for your ROCKS cluster and https://ip:port for your OCP on Z cluster (links to both will be shown as part of the job)
6. clone the repo you forked in step 1.
7. Change the `Hello World` on Line 14 in the code to anything you prefer and commit and push your code to github

```
func HelloServer(w http.ResponseWriter, r *http.Request) {
    fmt.Fprintf(w, "Hello, World!") ← Modify this
}
```

8. Watch the Jenkins dashboard for activity and follow the links at end to get connectivity information to your code

As this job uses Github hooks, it'll automatically build after step 7.

> Note, how our Jenkinsfile has a mix of `node ('s390x')` and `node ('amd64')`.

## Tips for multi-architecture builds:

- Use multi-architecture base images. The official images on RedHat Container Registry and dockerhub of popular run-times are multi-arch enabled, signed and supported by their vendors (e.g IBM for the popular WebSphere Liberty runtime)
- Use multi-stage builds. You will store as many copies of binaries as architectures, so image size can creep up quickly
- Optimize for prod by stripping debug symbols, using UPX etc
- Use native architecture build environments instead of `buildx` for speed

> **Thats it ! You can now build your multi-architecture deployment pipeline on OpenShift across any public and private cloud environment !** 🎉

# IBM Multicloud Manager

TODO : More on IBM MCM

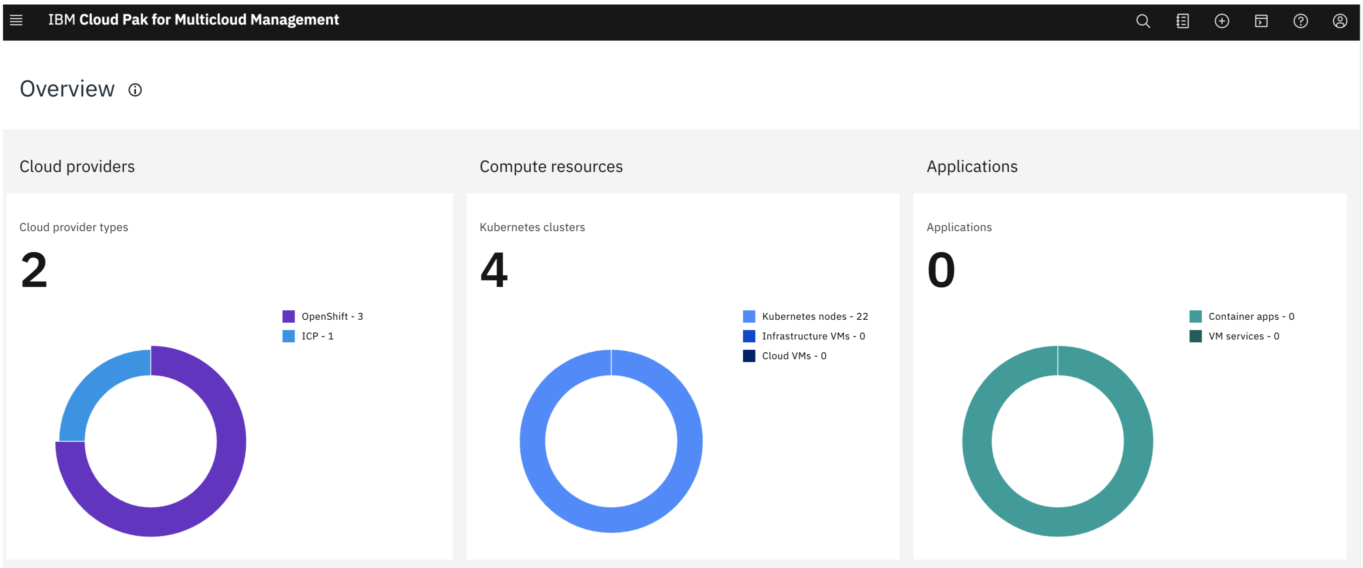
Using MCM you could add both OCP on Intel and Z clusters, setup a `podPlacementPolicy` and deploy your app to MCM and let MCM decide the best place to deploy it.

```
apiVersion: mcm.ibm.com/v1alpha1
 kind: PlacementPolicy
 metadata:
   name: prod-placement-policy
   namespace: mcm
 spec:
   clusterLabels:
     matchLabels:
       cloud: ibm-linuxone
```

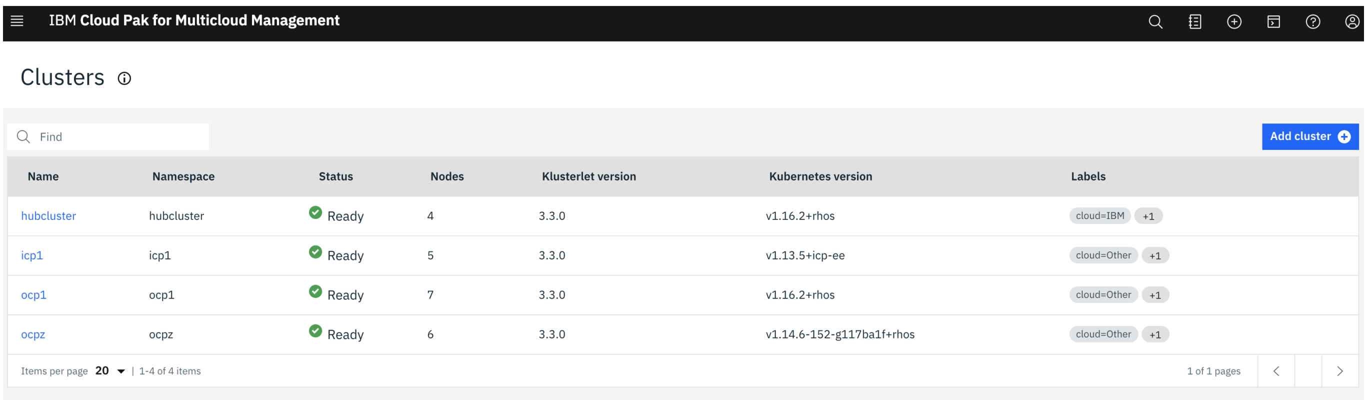
More details on placement policies can be found in the official IBM Multicloud Manager [documentation](#)

Our MCM cluster is setup with several kubernetes based PaaS clusters.

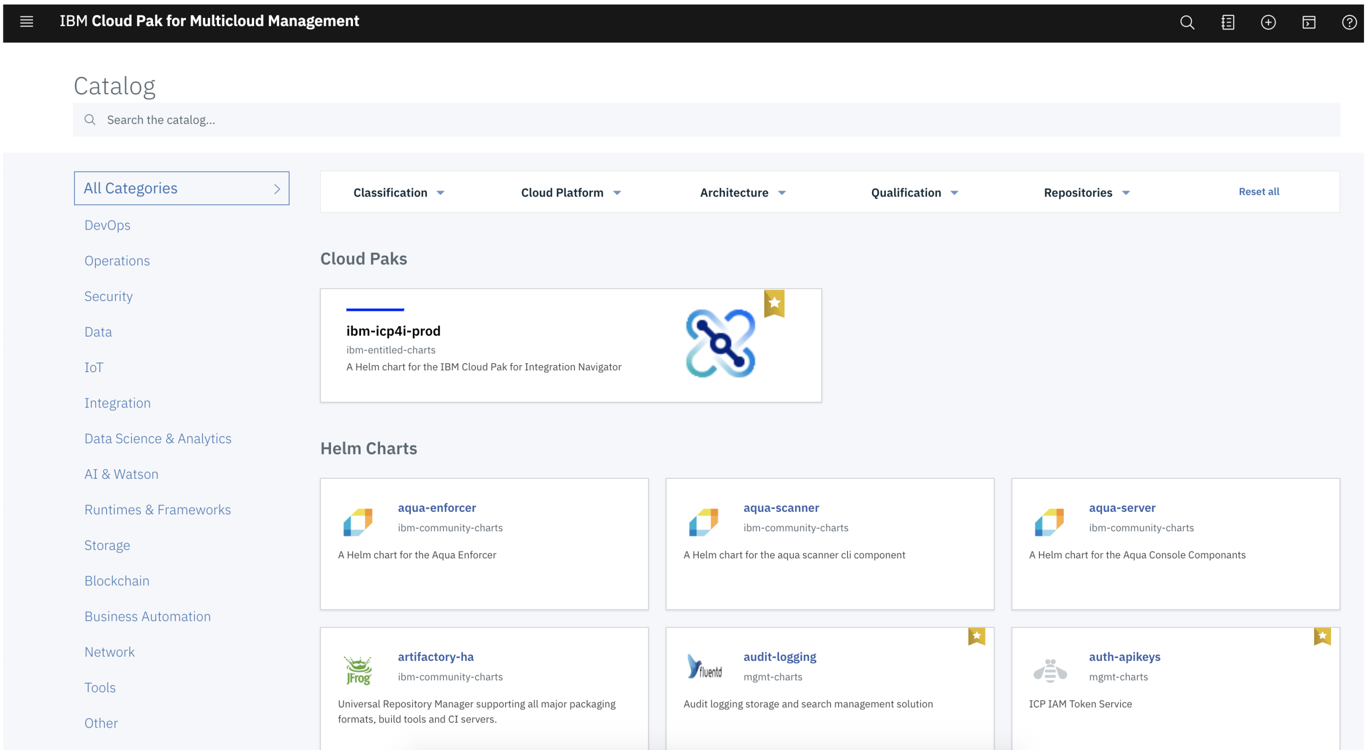
This shows the summary in a GUI:



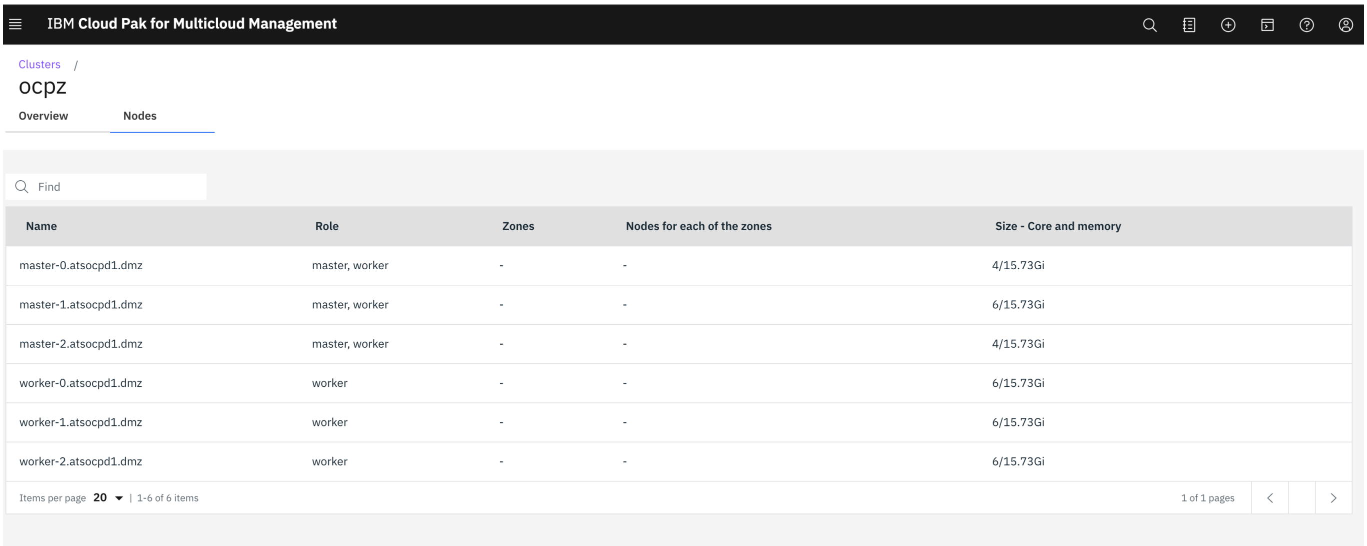

Cluster(s) health in a single view:



## Cross-cluster catalog:



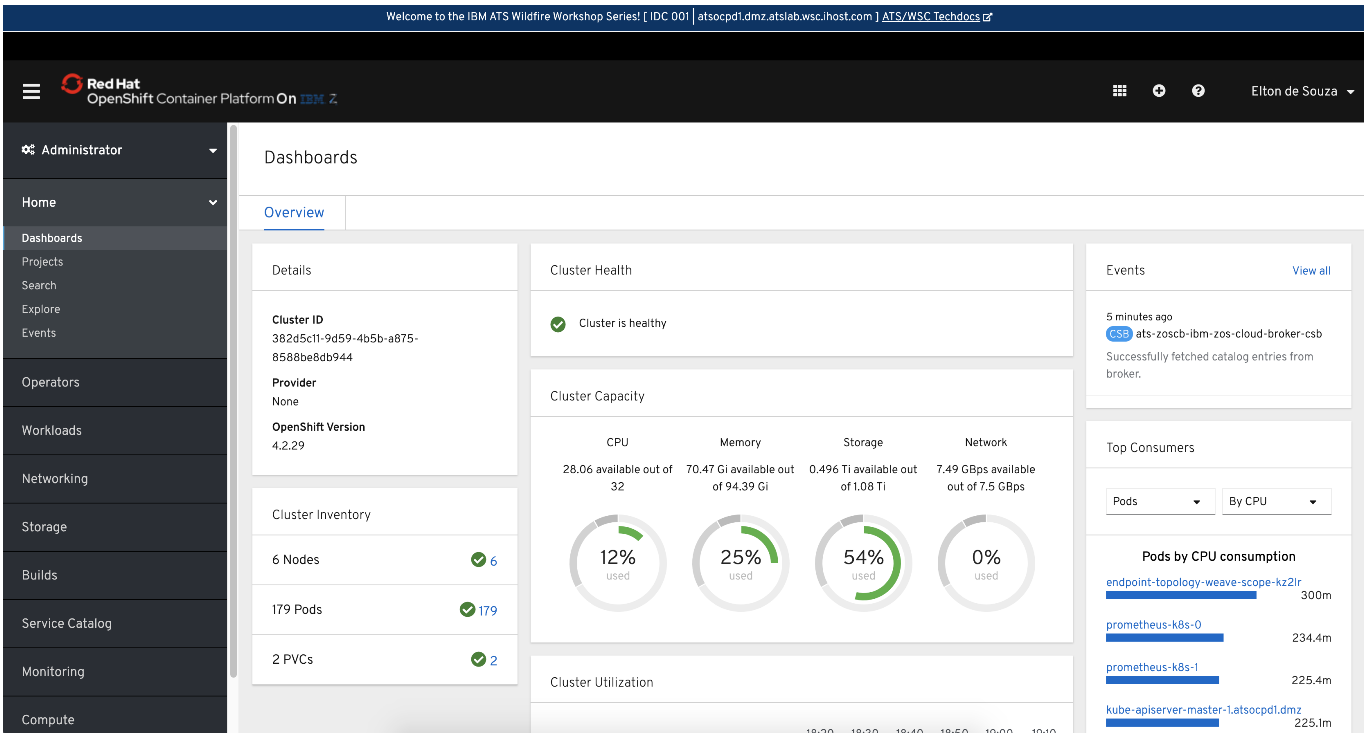

## Details about our specific OCP on Z cluster




| Name | Role | Zones | Nodes for each of the zones | Size - Core and memory |
|---|---|---|---|---|
| master-0.atsocpd1.dmz | master, worker | - | - | 4/15.73Gi |
| master-1.atsocpd1.dmz | master, worker | - | - | 6/15.73Gi |
| master-2.atsocpd1.dmz | master, worker | - | - | 4/15.73Gi |
| worker-0.atsocpd1.dmz | worker | - | - | 6/15.73Gi |
| worker-1.atsocpd1.dmz | worker | - | - | 6/15.73Gi |
| worker-2.atsocpd1.dmz | worker | - | - | 6/15.73Gi |

Items per page 20 | 1-6 of 6 items
1 of 1 pages

Clicking on the endpoint will take you to the OCP on Z Cluster:




In this scenario, I deployed WebSphere Liberty on OpenShift though IBM Multicloud Manager: