The State of APIs in the Container Ecosystem

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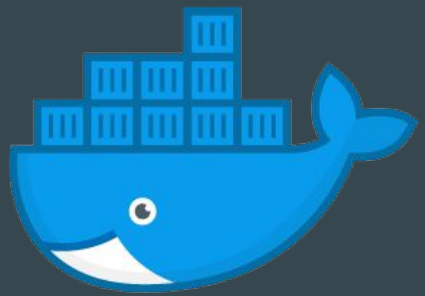
Developers, Developers, Developers

Docker led the container UX for developers **circa 2013-2014*

- Docker's command line was (and still is) a lightweight client
  - A well-defined HTTP-based REST API connected the client to the Docker engine
  - Usually local, but could be remote (*TCP with certificate auth, or SSH tunneled*)
- Developers love the command line, but APIs enable **integration** & **automation**
  - CI/CD, security tools, telemetry/monitoring, vendor extension points



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What's behind the Docker API?

A configuration

The heart of a container is the (JSON) representation of its configuration.

The command to run; the resources (cgroups), the isolation settings (namespaces), volumes, env variables, ...

An image bundle

The configuration is paired with the image metadata and layers of filesystem content

This is what is "built", and then possibly "pushed" and "pulled" from container registries.

A registry protocol

An HTTP API to query, inspect, fetch, and push content to a remote distribution endpoint.

For many this equates to DockerHub, but has grown to include many OSS projects and hosted registries.

The OCI:

> Configuration = The runtime spec
> Image = The image spec
> Registry = The distribution spec
> Runtime implementation = `runc`

But what about an **API** for containers?

Docker provided a solid answer for a single node.

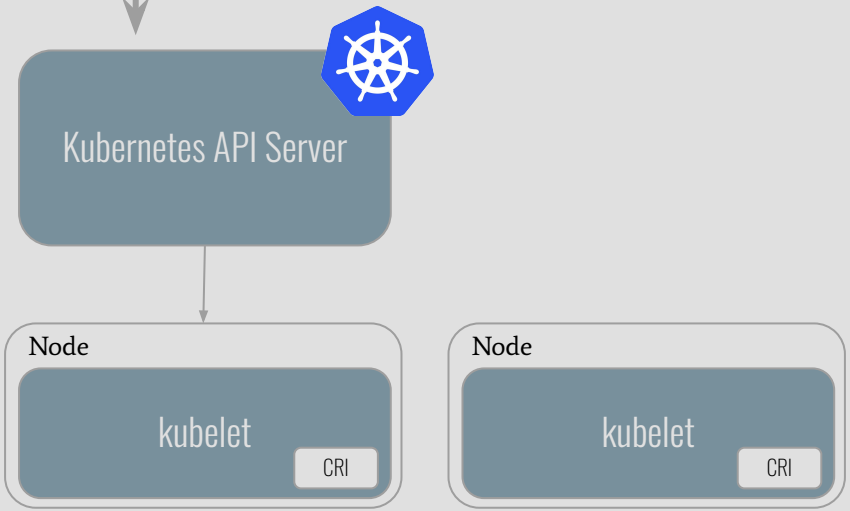
At scale, users need to orchestrate containers.

Cue: The orchestration wars..

But, really we only have time to talk about Kubernetes.

```
$ kubectl apply -f podspec.yaml
```

Kubernetes API over HTTP: <endpoint>:8081/api/v1/services



Kubelet → container runtime = gRPC endpoint implementing CRI

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Kubernetes API

Key component of the control plane for K8s object interaction

- CRUD operations via a REST API over HTTP on common objects
  - Examples: Pods, Nodes, Services, Deployments, Secrets, DaemonSet
  - `etcd` distributed database and “object” watchers handle operational flow to workers
- The power of Kubernetes is in the extensibility of this declarative state system
  - Can create and operate on new resource objects (CRDs)
  - Custom controllers can handle operations related to a custom resource

Kubernetes: The Container Runtime Interface (CRI)

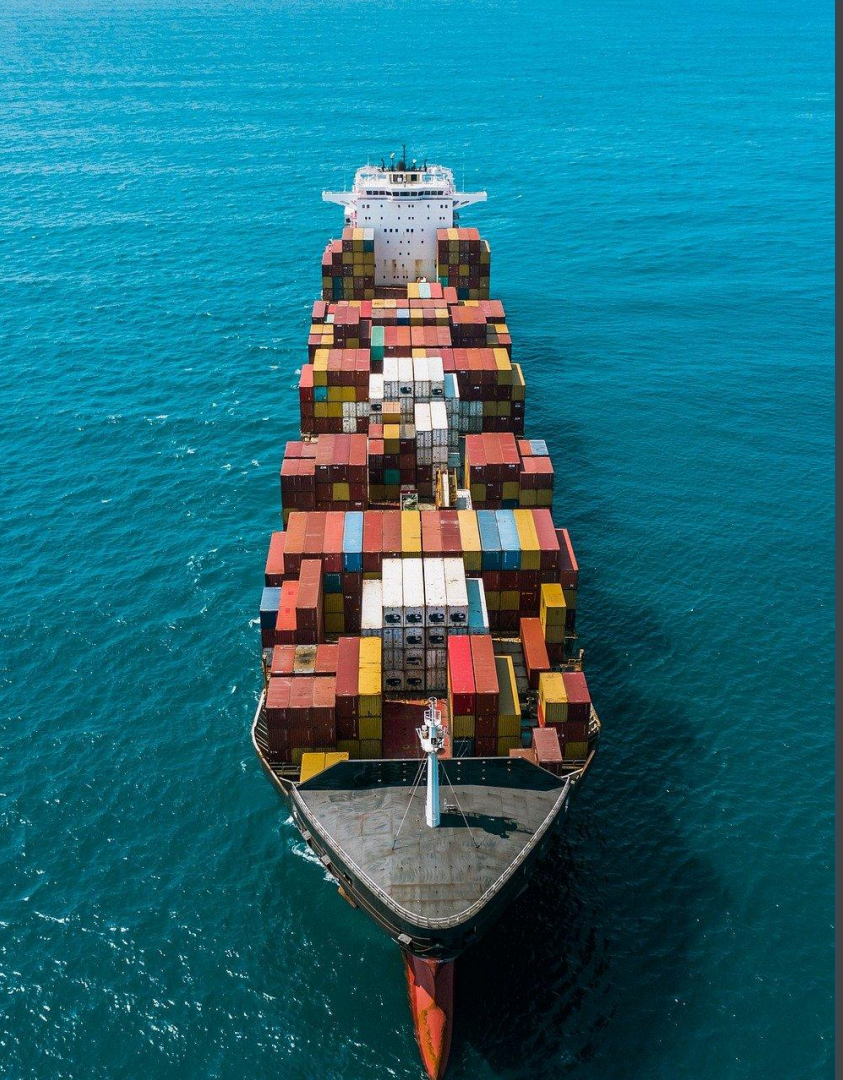
Allows an OCI compliant container runtime to service the kubelet

- Today the CRI is the (only?) common API for runtimes
  - However, CRI is not used outside of the Kubernetes ecosystem (today)
  - Implementing the CRI requires a runtime to represent a “pod sandbox”, not just containers
- The *dockershim* implementation is deprecated and removed as of K8s 1.24
  - All runtimes must provide a CRI-implementing endpoint:
    - Today: cri-o, containerd, Docker (provided by Mirantis), and Singularity

Kubernetes API Summary:

> HTTP/REST client API for K8s object model
> CRI over gRPC for kubelet - runtime
> Containers and images are OCI compliant

But what about an **API** for containers?



“Build. Ship. Run.”

*(from an **API** perspective)*

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Do APIs exist for “Build, Ship and Run”?

Build.

Dockerfile is not a standard, but effectively a de-facto standard.

What really matters is the output: build tools take many inputs & provide unique capabilities but all produce OCI compliant images.

Ship.

Yes! The registry/distribution protocol is an OCI standard today.

Pushing and pulling images (and related artifacts) is standardized and the API is stable and well-understood.

Run.

In the Kubernetes context, yes; the K8s API is clearly defined and adopted. At the runtime layer only the formats are standardized

CRI is the common factor among major runtimes. Underlying OCI types are standardized.

Build

- Use of traditional Dockerfile + base image workflows remain significant
  - Docker build, BuildKit, buildah, and many others
  - The “API” is the Dockerfile de-facto syntax standard; innovation favors BuildKit
- Many tools now combine build workflows with K8s dev and deployment
  - Skaffold
  - Tekton
  - Kaniko
  - ..and many vendor tools that integrate CI/CD, GitOps, etc. with traditional build operations
- Interesting projects
  - “ko” - static Go binary build and push integrated with many other tools
  - Buildpacks (CNCF)
  - dagger.io

Ship

- Given the common registry/distribution API and common format (OCI) most build tools directly handle the “ship” step to **any** OCI compliant registry
  - All the build tools listed on the last slide support pushing images to cloud services, on-prem, or self-hosted registries
- Innovations around “ship” will most likely come via “artifacts” support
  - Signing support: cosign/sigstore & Notary v2
  - Software Bill of Materials (SBOM)
  - Bundling (images + Helm charts + ?)
- Artifact and signing support are being collaborated on in various OCI and CNCF working groups, hopefully leading to common APIs and common formats

Run

User/Consumer

- K8s or something else?
  - With Kubernetes, you will have many options for additional abstractions, depending on managed service, roll-your-own, etc. APIs will be common across tools (e.g. K8s API, Knative, OpenFaaS, CF, ..)
- Non-K8s container orchestration
  - Google Cloud Run
  - AWS Fargate/AWS EC2
  - Hashicorp Nomad
  - Cycle.io, Azure Container Instances

Builder/Vendor

- Stay in the CNCF/K8s ecosystem?
  - Build/extend/integrate with the Kubernetes API/control plane
  - Common API, broad adoption means lots of building blocks & integrations
- Container runtime support:
  - Easy path: CRI support/integration within K8s context
  - No clean option for integrating with >1 specific runtimes; potential at lowest layer (runc/OCI hooks) but has drawbacks

Decision Points

> Docker engine & API still a valid single node solution

Lots of tools/integrations, compose, and podman implements API
Nerdctl+containerd providing a similar (client) experience sans Docker

> Kubernetes provides the most adopted platform for tools/APIs

Allows for broad standardization from developer toolsuite to production

> Most likely will adopt other APIs adjacent to K8s or containers

Cloud provider, infrastructure platform, cloud services (storage, network)

The API Future

Significant innovation around runtimes/APIs will stay in Kubernetes

- SIG-Node, Kubelet, and OCI communities will innovate up through the stack to enhance container capabilities
  - KEPs for user namespaces, checkpoint/restore, swap support
  - Bonus that work done at these layers is implemented in all CRI runtimes and exposed via common APIs
- No clear path to commonality at the runtime layer itself
  - Effectively two main camps: Docker/containerd/runc or cri-o/podman/buildah/crun
  - Different design ideologies mean no real path to a common API for runtimes outside of CRI

Thank You!

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