Creating a Reproducible Build System for Docker Images

(Or any OCI Compatible Runtime)

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Today's Topics

- Define “containers” in the context of Linux systems
  - Brief History/Background
  - Quick Tour of Linux Container Ecosystem
- Docker
- Docker Build (Dockerfile)
- Release Engineering
- Docker Layered Image Build Service
  - OpenShift
  - OpenShift Build Service (OSBS)
  - Koji-containerbuild
- Fedora’s Docker Layered Image Build Service
- Q&A
What are containers?

- Operating-system-level Virtualization
  - We (the greater Linux community) like to call them “containers”
- OK, so what is Operating-system-level Virtualization?
  - The multitenant isolation of multiple user space instances or namespaces.

![Diagram showing traditional OS and containers](image-url)
Containers are not new

The concept of containers is not new
- chroot was the original “container”, introduced in 1982
  - Unsophisticated in many ways, lacking the following:
    - COW
    - Quotas
    - I/O rate limiting
    - cpu/memory constraint
    - Network Isolation
- Brief (not exhaustive) history of sophisticated UNIX-like container technology:
  - 2000 - FreeBSD jails
  - 2001 – Linux Vserver
  - 2004 – Solaris Zones
  - 2005 - OpenVZ
  - 2008 – LXC
    - This is where things start to get interesting
Modern Linux Container is Born

- 2008 - IBM releases LinuX Containers (LXC)
  - Userspace tools to effectively wrap a chroot in kernel namespaces and cgroups
  - Provided sophisticated features the chroot lacked

- 2011 – systemd nspawn containers
  - Run a command or OS in a light-weight namespace container. Like chroot, but virtualizes the file system hierarchy, process tree, various IPC subsystems, host and domain name.

  - Originally used LXC as the backend, introduces the Docker daemon, layered images, standard toolset for building images and a distribution method (docker registry). Later makes backend driver pluggable and replaces LXC with libcontainer as default. Then later replaces backend with runc.
Modern Linux Container

- 2014 – CoreOS releases rkt (https://github.com/coreos/rkt)
  - rkt is an implementation of App Container(appc) specification and App Container Image(ACI) specification, built on top of systemd-nspawn.
  - ACI and appc aimed to be a cross-container specification to be a common ground between container implementations.

  - “The Open Container Initiative is a lightweight, open governance structure, to be formed under the auspices of the Linux Foundation, for the express purpose of creating open industry standards around container formats and runtime.” - http://opencontainers.org/

Modern Linux Container

- 2015 - Cloud Native Computing Foundation (CNCF - https://cncf.io/)
  - The Foundation’s mission is to create and drive the adoption of a new computing paradigm that is optimized for modern distributed systems environments capable of scaling to tens of thousands of self healing multi-tenant nodes.
Modern Linux Container

- 2015 – runc (http://runc.io/)
  - Stand-alone command line tool for spawning containers as per the OCP specification.
  - Containers are child processes of runC, no system daemon, can be embedded.
  - Shares technology lineage with Docker (libcontainer and others).
  - Compatible with Docker images.
  - Docker Engine v1.11+

- 2016 – containerd (http://containerd.tools/)
  - Containerd is a daemon with an API and a command line client, to manage containers on one machine. It uses runC to run containers according to the OCI specification.
  - Docker Engine v1.11+
Docker

- Docker Engine (daemon) is the single point of entry, has language bindings for other clients and tooling. (Image verification)
- **Containers** are instances of **images**.
- Images are built in a standard way using Dockerfile
- SELinux support upstream in Docker.
- Pluggable backends for isolation mechanism, storage, networking, etc.
Base vs Layered Images

Fedora 24 Host
HARDWARE OR VM

CONTAINER
Fedora 24
BASE IMAGE
Fedora 24
APP LAYER

Fedora 24 Host
HARDWARE OR VM

Fedora 25 Host
HARDWARE OR VIRTUAL MACHINE

Fedora 24
APP
Fedora 24
APP
Fedora 24
APP

Fedora 24
App
APP
LIBS
FROM fedora  
MAINTAINER http://fedoraproject.org/wiki/Cloud  

RUN dnf -y update && dnf clean all  
RUN dnf -y install httpd && dnf clean all  
RUN echo "HTTPD" >> /var/www/html/index.html  

EXPOSE 80  

# Simple startup script  
ADD run-httpd.sh /run-httpd.sh  
RUN chmod -v +x /run-httpd.sh  

CMD ["/run-httpd.sh"]
$ docker build -t fedora-httpd .
Sending build context to Docker daemon 24.06 kB
Step 1 : FROM docker.io/fedora
    ---> f9873d530588
Step 2 : MAINTAINER http://fedoraproject.org/wiki/Cloud
    ---> Running in d7c01855128e
    ---> 819fb0ed13b0
Removing intermediate container d7c01855128e
Step 3 : LABEL RUN 'docker run -d -p 80:80 $IMAGE'
    ---> Running in 4288ff446166
    ---> 5f2b85c9dbd73
Removing intermediate container 4288ff446166
Step 4 : RUN dnf -y update && dnf -y install httpd && dnf clean all
    ---> Running in df63942c3979
... OUTPUT OMITTED FOR BREVITY ...
Successfully built 63bc543a1868
· What is Release Engineering?
  · Making a software production pipeline that is Reproducible, Auditable, Definable, and Deliverable
    · It should also be able to be automated

· Definition (or the closest there really is)
  “Release engineering is the difference between manufacturing software in small teams or startups and manufacturing software in an industrial way that is repeatable, gives predictable results, and scales well. These industrial style practices not only contribute to the growth of a company but also are key factors in enabling growth.”
  
  - Boris Debic of Google Inc
Release Engineering
### OpenShift

#### Core Components

- **Self-Service**
- **Service Catalog** (Language runtimes, middleware, databases, ...)
- **Build Automation**
- **Deployment Automation**
- **Application Lifecycle Management** (CI / CD)
- **Container Orchestration & Cluster Management** (Kubernetes)
- **Networking**
- **Storage**
- **Registry**
- **Logs & Metrics**
- **Security**
- **Infrastructure Automation & Cockpit**
- **Container Runtime & Packaging** (Docker)
- **Atomic Host**

#### Operating Systems

- Fedora / CentOS / Red Hat Enterprise Linux

#### Environment Types

- Physical
- Virtual
- Private
- Public
OpenShift/Kubernetes Overview

Client

Master
- REST API
- Scheduler

Node

Pod
- Container
- Container
- Container

Pod
- Container
- Container
- Container

Pod
- Container
- Container
- Container
Docker Layered Image Build Service
Build System

- osbs cli
- OSBS
  - OpenShift Origin
  - atomic-reactor
  - osbs-client API
- Registry
  - Candidate Images
  - Stable + Updates
  - ...
- Users
- Server Deployments

Content Stream:
- RPMs
- pypi
- rubygem
- npm
- maven
- ...

Diagram shows the integration between the OSBS, Registry, and Users, with various content streams such as RPMs, pypi, rubygem, npm, and maven.
OpenShift Build Service

- Takes advantage of OpenShift’s built in Build primitive with a “Custom Strategy” and BuildConfig
  - This defines what can be the inputs to a build
- Relies on OpenShift for scheduling of build tasks throughout the cluster
- Presents this defined component to developers/builders as CLI and Python API
- osbs enforces that the inputs come from auditable sources.
  - Git repo for source Dockerfile, git commits and builds centrally logged
- BuildRoot - limited docker runtime
  - Firewall constrained docker bridge interface
  - Unprivileged container runtime with SELinux Enforcing
  - Inputs are sanitized before reaching to build phase
    - Unknown or unvetted sources are disallowed by the system
- Uses OpenShift ImageStreams as input sources to BuildRoot
- Utilizes OpenShift Triggers to spawn rebuild actions based on parent image changes
  - How often are your images rebuilt?
atomic-reactor
· Single-pass Docker build tool used inside constrained buildroot in OSBS
· Automates tasks via plugins, such as:
  · pushing images to a registry when successfully built
  · injecting yum/dnf repositories inside Dockerfile (change source of your packages for input sanitization/gating)
  · change base image (FROM) in your Dockerfile to
  · match that of the registry available inside the isolated buildroot, run simple tests after image is built
· Gating of updates
  · Automated tests can be tied to the output of OSBS
  · RelEng is able to then "promote" images to a "production" or "stable" registry/tag/repository
Fedora’s Implementation

Fedora Layered Image Maintainers

DistGit
- Dockerfile
- Service Scripts
- Tests
- Docs

Koji
- RPM Builds
- Container-build
- ISO/Cloud Images
- ...

Candidate Registry
- Candidate Images

OSBS
- OpenShift Origin
- atomic-reactor
- osbs-client API

Registry
- Stable + Updates

Users

Content Stream
- RPMs
- pypi
- rubygem
- npm
- maven
- ...

fedpkg container-build

Candidate Registry

Fedora’s Implementation

- **DistGit (“Distro Git”)**
  - Each Branch = Fedora Release
  - master branch is Devel (codename “Rawhide”)
- **fedpkg**
  - Fedora Package Maintainer helper tool
  - Manages distgit branches
  - Initiate builds (local and remote, mock integration)
  - Much more ...
- **Koji**
  - Fedora’s authoritative build system
  - Everything for Fedora is built here or it’s build is integrated here
    - Live USB images, DVD ISOs, IaaS Cloud Images, RPMs, Docker
    - This defines what can be the inputs to a build
- **Koji-containerbuild**
  - Plugin to orchestrate builds between Koji and OSBS
- **Registry**
  - Upload/download destination, point of distribution
What is Release Engineering?
- Making a software production pipeline that is Reproducible, Auditable, Definable, and Deliverable
  - It should also be able to be automated

Reproducible
- Given the same set of inputs we can expect the same set of outputs
  - We can even limit the specific versions of every artifact in the container

Auditable
- OSBS maintains a manifest of its inputs and outputs
- All actions are logged centrally
  - Fedora’s implementation also involves a message bus and archives all activity in a database

Definable
- OSBS defines an OpenShift Build, if definition violated the system will reject the build

Deliverable
- Gating for promoting content among Docker Image Registries/Tags/Repositories
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