Jetpack

A container runtime for FreeBSD

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BSDCan 2015

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Outline

OS-level Virtualization: Not a New Tech

The Container Mindset

Docker & Rocket

App Container Specification

Jetpack

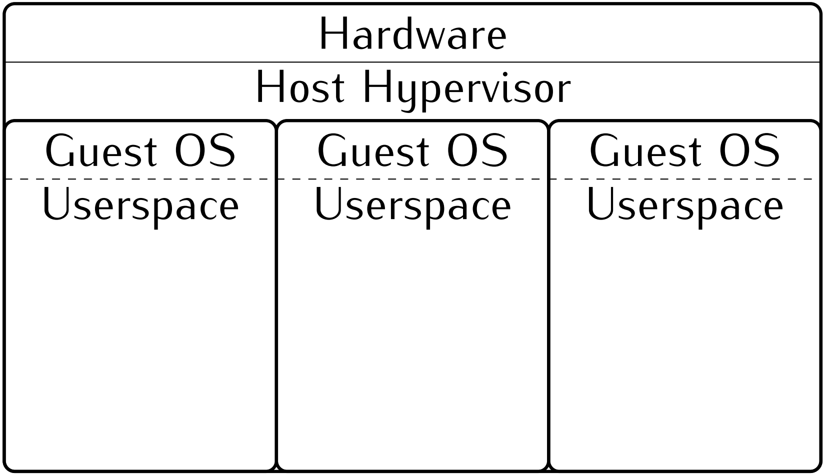
OS-level Virtualization

Single host kernel

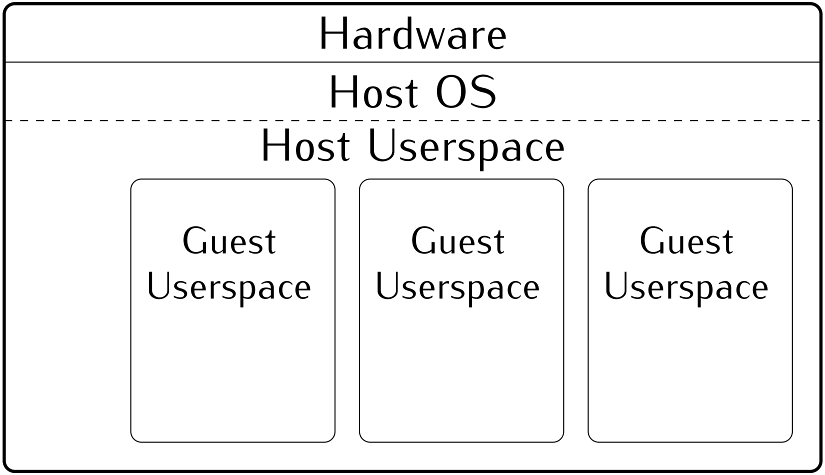
$\Downarrow$

Multiple guest userspaces

Hypervisor–type Virtualisation



OS-level Virtualisation



OS-level Virtualization

versus hypervisor

- Less isolation
- Guest & host OS must be the same[1]
- Lower overhead
- Adjustable isolation level
- Resource sharing is possible

[1] or binary-compatible: Solaris branded zones, FreeBSD Linuxulator

1982: The Stone Age

chroot(2)

```
CHROOT(2)                 FreeBSD System Calls Manual                 CHROOT(2)

NAME
     chroot – change root directory

LIBRARY
     Standard C Library (libc, -lc)

SYNOPSIS
     #include <unistd.h>

     int
     chroot(const char *dirname);

DESCRIPTION
     The dirname argument is the address of the pathname of a directory,
     terminated by an ASCII NUL.  The chroot() system call causes dirname to
     become the root directory, that is, the starting point for path searches
     of pathnames beginning with ‘/’.
```

1998–2012: The Industrial Age

1998	FreeBSD Jail
2001	Linux–VServer, Virtuozzo
2005	OpenVZ, Solaris Containers
2008	Linux cgroups, LXC

1998–2012: The Industrial Age

- Isolated filesystem, process tree, networking
- Restricted interaction between environments
- Restricted administrative system calls
- Resource usage limits

VM Mindset

Guest is a complete system:

- managed from the inside
- runs multiple services
- long-running and mutable
- opaque to host

Management overhead of a whole server

2013: Modern Age

Jan 2013	Docker
Dec 2014	App Container Specification, CoreOS Rocket
Jan 2015	Jetpack

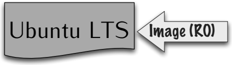
2013: Modern Age

- Inspired by PaaS, service–oriented
- Guest managed from the outside
- Immutable, distributable images
- Fast copy-on-write provisioning

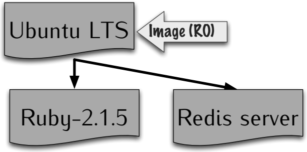
Container Mindset

- Layered storage
- Explicit interaction points
- Immutable images, volatile containers
- Service-oriented

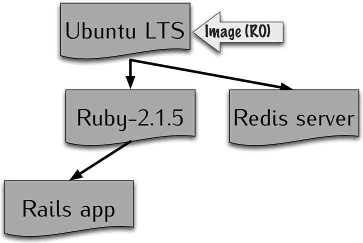
Layered Storage



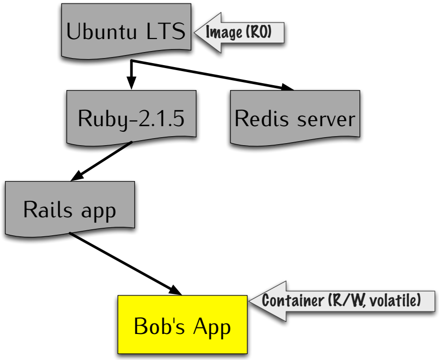
Layered Storage



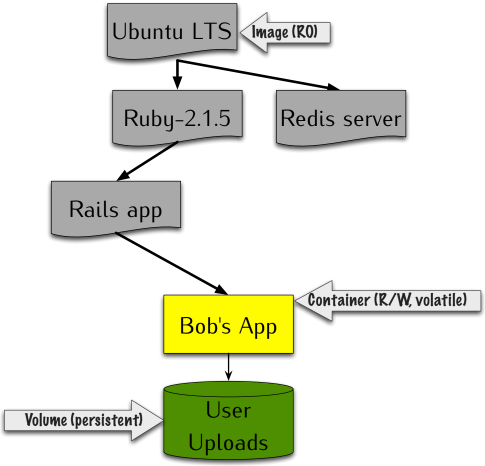
Layered Storage



Layered Storage



Layered Storage



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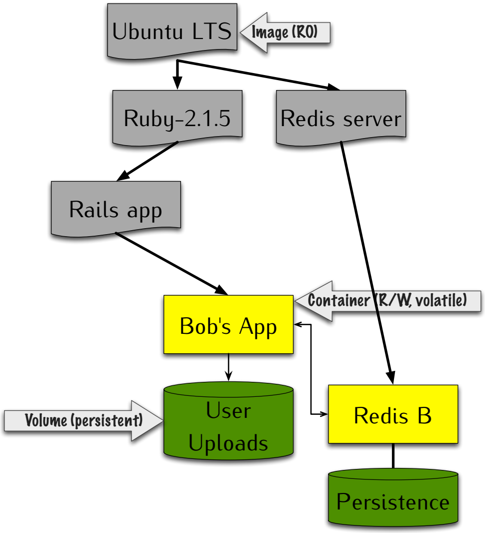
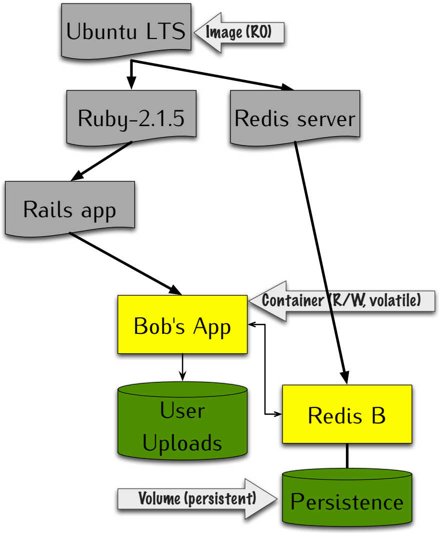
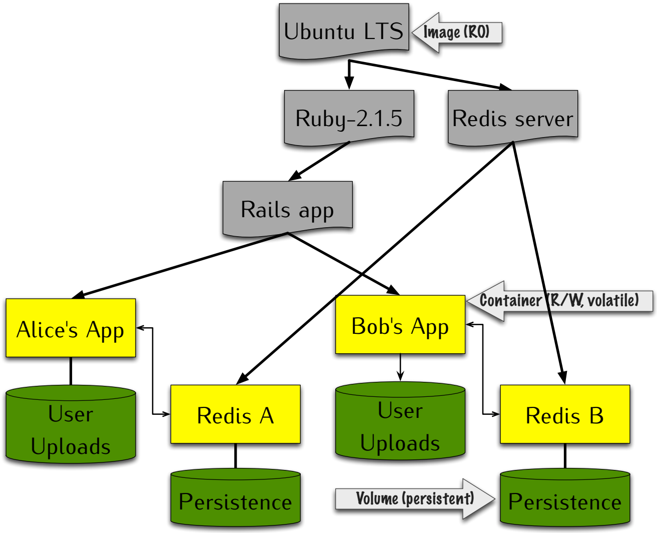


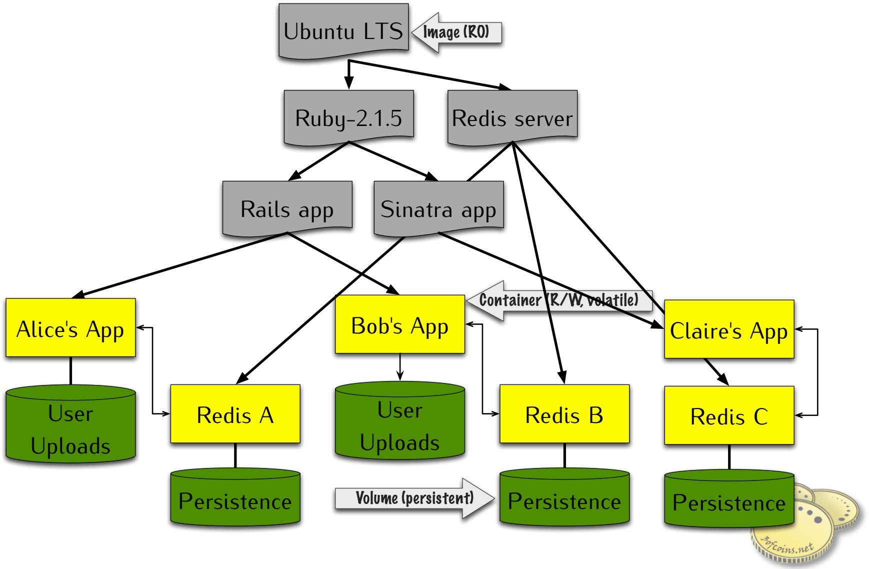
Layered Storage



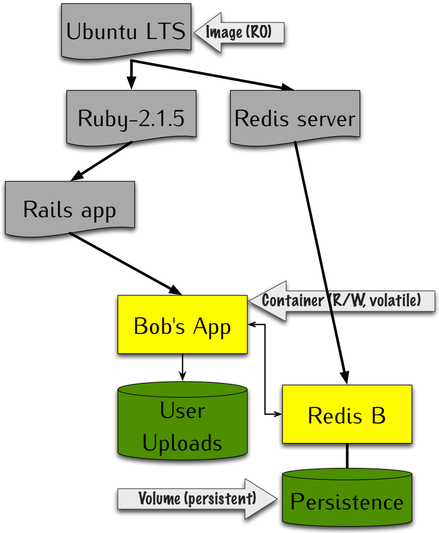
Layered Storage



Layered Storage



Layered Storage



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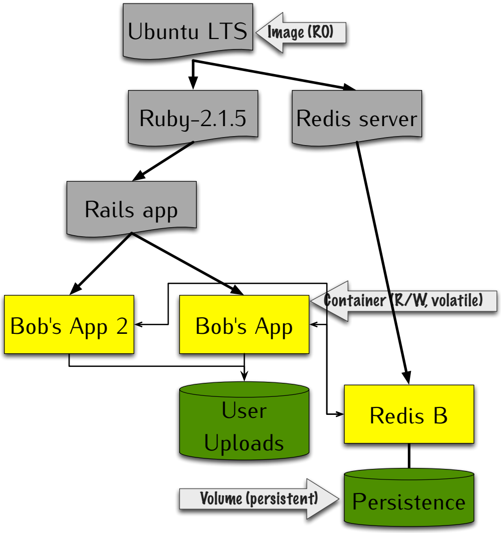

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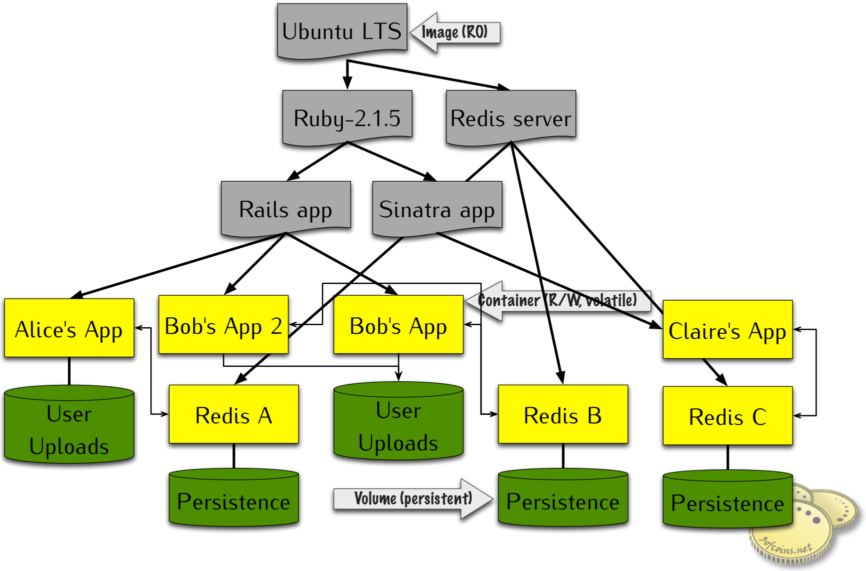

Explicit Interaction Points

- Command line arguments
- Environment variables
- Network ports
- Persistent/shared volumes
- Stdin, stdout, stderr
- Exit status

Immutability

- Images, once built, are read-only
- Containers' write layer is throwaway
- Volumes are persistent and shareable

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- Containers' write layer is throwaway
  ⇒ exchangeable; upgradeable
- Volumes are persistent and shareable
  ⇒ precious user data is clearly declared

Service-oriented

- Well-defined images can be shared & reused across applications
- Containers can be meaningfully managed & monitored by host

Management overhead of a single service

Docker

- First free container runtime
- Defined the container paradigm
- Extremely fast & wide adoption
- Implementation-driven

https://www.docker.com/

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  ⇒ prototyped it
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  - ⇒ locked into early design decisions
- Implementation-driven
  - ⇒ Implementation-defined

https://www.docker.com/

The management question, therefore, is not whether to build a pilot system and throw it away. You will do that. [...] Hence plan to throw one away; you will, anyhow.

— Fred Brooks, *The Mythical Man–Month*

CoreOS Rocket

- First implementation of the *appc* specification
- Designed for “composability, security, and speed”
- Breaks Docker monoculture
- Linux-only

https://github.com/coreos/rkt

App Container Specification

AKA *appc*

appc/spec

- Composable
- Secure
- Decentralized
- Open

App Container Image (*ACI*)

- A compressed *tar* file containing:
  - `manifest` JSON file
  - `rootfs/` directory
- Identified by SHA–512 checksum (before compression)
- Addressed by *name* and a set of *labels*

https://github.com/appc/spec/blob/master/spec/aci.md

ACI Manifest

```
{ "acKind": "ImageManifest",
  "acVersion": "0.5.2",
  "name": "demo/bsdcan2015/redis",
  "labels": [ { "name": "version", "value": "3.0.2" },
              { "name": "os",      "value": "freebsd" },
              { "name": "arch",    "value": "amd64" } ],
  "app": { "exec": [ "/usr/local/bin/redis-server",
                     "/usr/local/etc/redis.conf" ],
           "user": "redis",
           "group": "redis",
           "mountPoints": [
             { "name": "redis-datadir", "path": "/var/db/redis" } ],
           "ports": [
             { "name": "redis", "protocol": "tcp", "port": 6379 } ] },
  "annotations": [
    { "name": "timestamp", "value": "2015-06-12T19:41:25-04:00" }],
  "dependencies": [{
    "app": "3ofcoins.net/freebsd-base",
    "imageID": "sha512-a9c9…91d0",
    "labels": [ { "name": "version", "value": "10.1.12" },
                { "name": "os",      "value": "freebsd" },
                { "name": "arch",    "value": "amd64" } ]
  }] }
```

App Container Image Discovery

From ACI name & labels to:

- ACI URL
- ACI Signature URL
- Public Key URL

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

From ACI name & labels to:

- ACI URL
- ACI Signature URL
- Public Key URL

name	3ofcoins.net/freebsd-base
labels	version=10.1.12
	os=freebsd
	arch=amd64

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

Simple Discovery

First, try to just use name as base URL:

- https://{name}-{version}-{os}-{arch}.aci
- https://{name}-{version}-{os}-{arch}.aci.asc
- No public key discovery

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

Simple Discovery

First, try to just use name as base URL:

- https://{name}-{version}-{os}-{arch}.aci
- https://{name}-{version}-{os}-{arch}.aci.asc
- No public key discovery

https://3ofcoins.net/freebsd-base-
-10.1.12-freebsd-amd64.aci

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

Meta Discovery

Go to https://{name}?ac-discovery=1

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

Meta Discovery

Go to https://{name}?ac-discovery=1

Look for:

```
<meta name="ac-discovery" content="prefix-match url-tmpl">
<meta name="ac-discovery-pubkeys" content="prefix-match url">
```

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

Meta Discovery

Go to https://{name}?ac-discovery=1

Look for:

```
<meta name="ac-discovery" content="prefix-match url-tmpl">
<meta name="ac-discovery-pubkeys" content="prefix-match url">
```

If that fails, strip last component off *name* and try again.

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

Meta Discovery

Go to https://{name}?ac-discovery=1

Look for:

```
<meta name="ac-discovery" content="prefix-match url-tmpl">
<meta name="ac-discovery-pubkeys" content="prefix-match url">
```

If that fails, strip last component off *name* and try again.

Rinse. Repeat.

https://github.com/appc/spec/blob/master/spec/discovery.md

App Container Image Discovery

Meta Discovery

https://3ofcoins.net/freebsd-base?ac-discovery=1

App Container Image Discovery

Meta Discovery

https://3ofcoins.net/freebsd-base?ac-discovery=1 $\Rightarrow$404

App Container Image Discovery

Meta Discovery

https://3ofcoins.net/freebsd-base?ac-discovery=1 ⇒404
https://3ofcoins.net?ac-discovery=1

App Container Image Discovery

Meta Discovery

https://3ofcoins.net/freebsd-base?ac-discovery=1 ⇒404

https://3ofcoins.net?ac-discovery=1

```
<meta name="ac-discovery" content="3ofcoins.net
↪  https://3ofcoins-aci.s3.eu-central-1.amazonaws.com/{name}-
↪  {version}-{os}-{arch}.{ext}">
<meta name="ac-discovery-pubkeys" content="3ofcoins.net
↪  https://3ofcoins-aci.s3.eu-central-1.amazonaws.com/aci-
↪  pubkeys.asc">
```

App Container Image Discovery

Meta Discovery

https://3ofcoins.net/freebsd-base?ac-discovery=1 ⇒404

https://3ofcoins.net?ac-discovery=1

```
<meta name="ac-discovery" content="3ofcoins.net
↪  https://3ofcoins-aci.s3.eu-central-1.amazonaws.com/{name}-
↪  {version}-{os}-{arch}.{ext}">
<meta name="ac-discovery-pubkeys" content="3ofcoins.net
↪  https://3ofcoins-aci.s3.eu-central-1.amazonaws.com/aci-
↪  pubkeys.asc">
```

https://3ofcoins-aci.s3.eu-central-1.amazonaws.com/...

.../3ofcoins.net/freebsd-base-10.1.12-freebsd-amd64.aci

.../3ofcoins.net/freebsd-base-10.1.12-freebsd-amd64.aci.asc

.../aci-pubkeys.asc

appc Pods

A list of apps that will be launched together inside a shared execution context

- Shared PID space, network, IPC, hostname
- Separate filesystem root for each app
- Shared, persistent volumes
- Isolators

https://github.com/appc/spec/blob/master/spec/pods.md

Pod Manifest

template

```
{ "acVersion": "0.5.2",
  "acKind": "PodManifest",
  "apps": [
    { "name": "redis",
      "image": { "name": "demo/bsdcan2015/redis" },
      "mounts": [{ "volume":     "redis-datadir",
                   "mountPoint": "redis-datadir" }] },
    { "name": "tipboard",
      "image": { "name": "demo/bsdcan2015/tipboard" },
      "mounts": [{ "volume":     "tipboard",
                   "mountPoint": "tipboard" }] }],
  "volumes": [
    { "name": "tipboard", "kind": "host", "readOnly": true,
      "source": "/home/japhy/Documents/20150607-bsdcan2015-
      ↪  jetpack/demo/data"
    }] }
```

Pod Manifest

reified

```
{ "acVersion": "0.5.2",
  "acKind": "PodManifest",
  "apps": [
    { "name": "redis",
      "image": { "name": "demo/bsdcan2015/redis",
                 "id": "sha512-a9c9…91d0" },
      "mounts": [{ "volume":     "redis-datadir",
                   "mountPoint": "redis-datadir" }] },
    { "name": "tipboard",
      "image": { "name": "demo/bsdcan2015/tipboard",
                 "id": "sha512-8a6d…f0fb" },
      "mounts": [{ "volume":     "tipboard",
                   "mountPoint": "tipboard" }] }],
  "volumes": [
    { "name": "redis-datadir", "kind": "empty" },
    { "name": "tipboard",      "kind": "host", "readOnly": true,
      "source": "/home/japhy/Documents/20150607-bsdcan2015-
      ↪  jetpack/demo/data"
    }],
  "annotations": [
    { "name": "ip-address", "value": "172.23.0.2" } ]}
```

appc Executor

Executor Perspective

- Assigns pod UUIDs
- Renders apps' filesystems
- Sets up volumes
- Configures network
- Collects logs from stdout & stderr

https://github.com/appc/spec/blob/master/spec/ace.md

appc Executor

App Perspective

- Environment variables, UID, GID, working directory as per image/pod manifest
- Resource isolation
- Access limits
- Metadata service

https://github.com/appc/spec/blob/master/spec/ace.md

appc Metadata Service

$AC_METADATA_URL/acMetadata/v1/...

- /pod/annotations/NAME
- /pod/manifest (fully reified)
- /pod/UUID
- /apps/*$AC_APP_NAME*/...
  - /annotations/NAME
  - /image/manifest
  - /image/id

https://github.com/appc/spec/blob/master/spec/ace.md

appc Metadata Service

$AC_METADATA_URL/acMetadata/v1/…

- /pod/hmac/sign — POST to have ACE sign any data as this pod
- /pod/hmac/verify — verify another pod's (or own) signature on data

https://github.com/appc/spec/blob/master/spec/ace.md

Jetpack

App Container Specification implementation for FreeBSD[1]

3ofcoins/jetpack

[1](not production ready)

Jetpack

- Written in Go
- Jails for process isolation & lockdown
- ZFS for layered storage
- Runs Linux images (as allowed by FreeBSD's emulation)
- Breaks Linux monoculture (hopefully)
- Half year old this Monday

https://github.com/3ofcoins/jetpack/

Jetpack: ZFS Storage

- Each image's *rootfs* is a ZFS snapshot
- Dependent image's *rootfs* is cloned from parent, then updated
- Pod app's *rootfs* is cloned from image
- Each empty volume is a ZFS dataset

Jetpack: Runtime

- Jail for pod isolation
- Each app has additional `chroot(2)` inside jail's fs root
- Volumes are `nullfs(5)` mounts

Jetpack: Image Building

```
jetpack image IMG build -dir=. CMD ARGS…
```

- Clone new pod from *IMG*
- Copy *build dir* to a new directory
- Run build command *CMD…* in the build dir
- Copy new manifest from build dir
- Use pod's rootfs (without build dir) as new image's

https://github.com/3ofcoins/jetpack/blob/master/IMAGES.md

Jetpack: Image Building

```
.MAKEFLAGS: -I${HOME}/Src/github.com/3ofcoins/jetpack/share

PARENT_IMAGE = 3ofcoins.net/freebsd-base
PKG_INSTALL = python27 py27-virtualenv libyaml

basedir=/opt/tipboard
projdir=${basedir}/home/.tipboard
build:
        virtualenv ${basedir}
        ${basedir}/bin/pip install tipboard
        install -m 0755 pre-start.sh ${basedir}/bin/pre-start.sh
        install -d ${basedir}/data ${projdir}
        install settings-local.py ${projdir}/settings-local.py
        ln -s /dev/null ${basedir}/home/tipboard.log
        install -m 0755 tipboard.sh /usr/local/bin/tipboard

manifest.json:
        ./manifest.json.sh > $@

.include "jetpack.image.mk"
```

https://github.com/3ofcoins/jetpack/blob/master/IMAGES.md

Jetpack: Image Building

```
#!/bin/sh
set -e

version="$(tipboard --version)"
version="${version#Tipboard }"

cat <<EOF
{
  "name": "demo/bsdcan2015/tipboard",
  "labels": [{ "name": "version", "value": "${version}" }],
  "app": {
    "exec": ["/usr/local/bin/tipboard", "runserver", "0.0.0.0", "7272"
    "eventHandlers": [
      { "name": "pre-start", "exec": [ "/opt/tipboard/bin/pre-start.sh
    "user": "www",
    "group": "www",
    "ports": [{ "name": "http", "protocol": "tcp", "port": 7272 }],
    "mountPoints": [{ "name": "tipboard", "path": "/opt/tipboard/data"
  }
}
EOF
```

https://github.com/3ofcoins/jetpack/blob/master/IMAGES.md

Jetpack: Image Building

```python
import os, os.path, urllib

execfile(os.path.expanduser("~/.tipboard/settings.py"))

AC_MDS_BASE = os.getenv('AC_METADATA_URL') + '/acMetadata/v1'
REDIS_HOST = urllib.urlopen(
    MDS_BASE+'/pod/annotations/ip-address').read()
REDIS_PORT = 6379
```

https://github.com/3ofcoins/jetpack/blob/master/IMAGES.md

Jetpack: TODO

- Isolators
- *pf* anchor management
- Better UI: commands, output
- Boring stuff: docs, acceptance tests
- Native multi-app pod support
- Logging

https://github.com/3ofcoins/jetpack/

Demo time!

Questions?

3ofcoins/jetpack

3ofcoins.net