redhat.

Database Containers: Made by Distributions

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The goal today

- Get feedback
- Show how we think about containers
- Convince you that you shouldn’t ignore them
- Introduce technologies that we care about in Red Hat

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- Red Hat, Platform Engineering
- Databases, Python, Ruby
- RHEL, Fedora, CentOS
- Software Collections

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- **AND CONTAINERS**

What this talk includes

1. Containers basics
2. Why containers matter
3. PostgreSQL Docker container
4. System containers
5. Tools containers
6. GUI apps in containers
7. OS containers
8. Ansible Containers
9. OCI

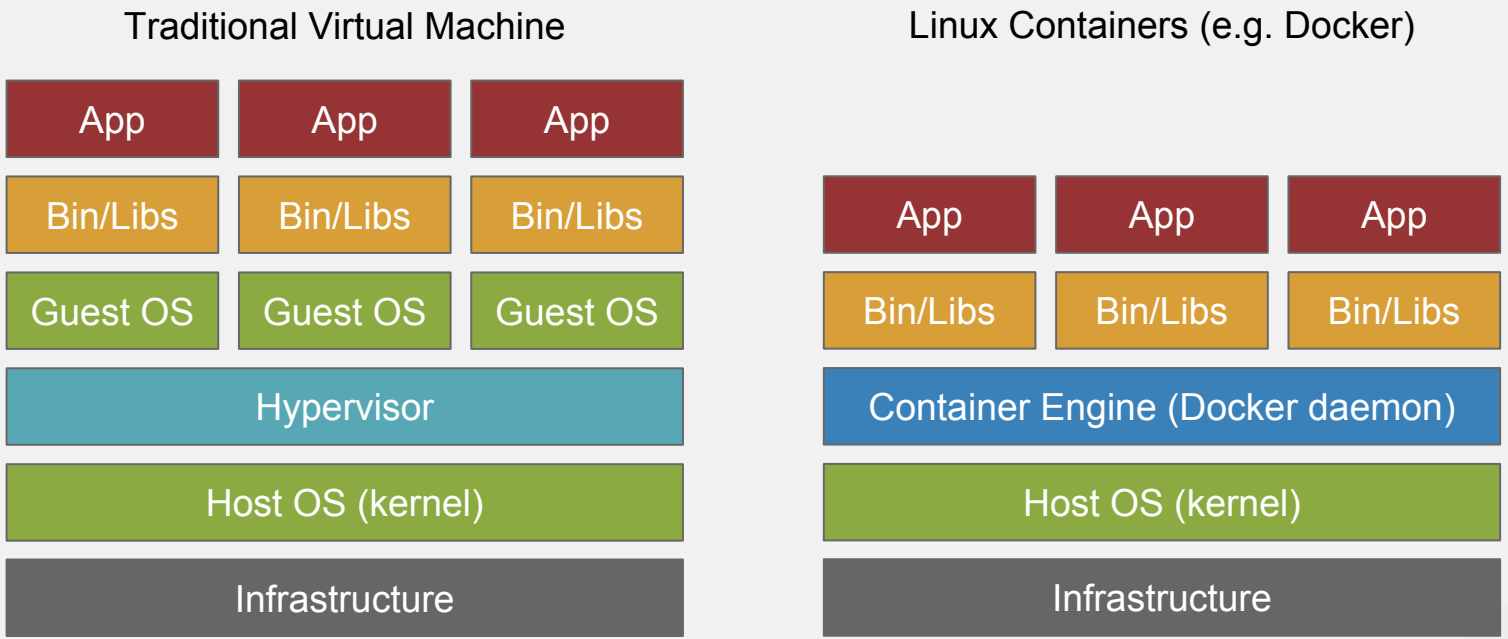
1. CONTAINERS BASICS


ВАТ "Київспецтранс"
ТЕЛ. 400-10-11

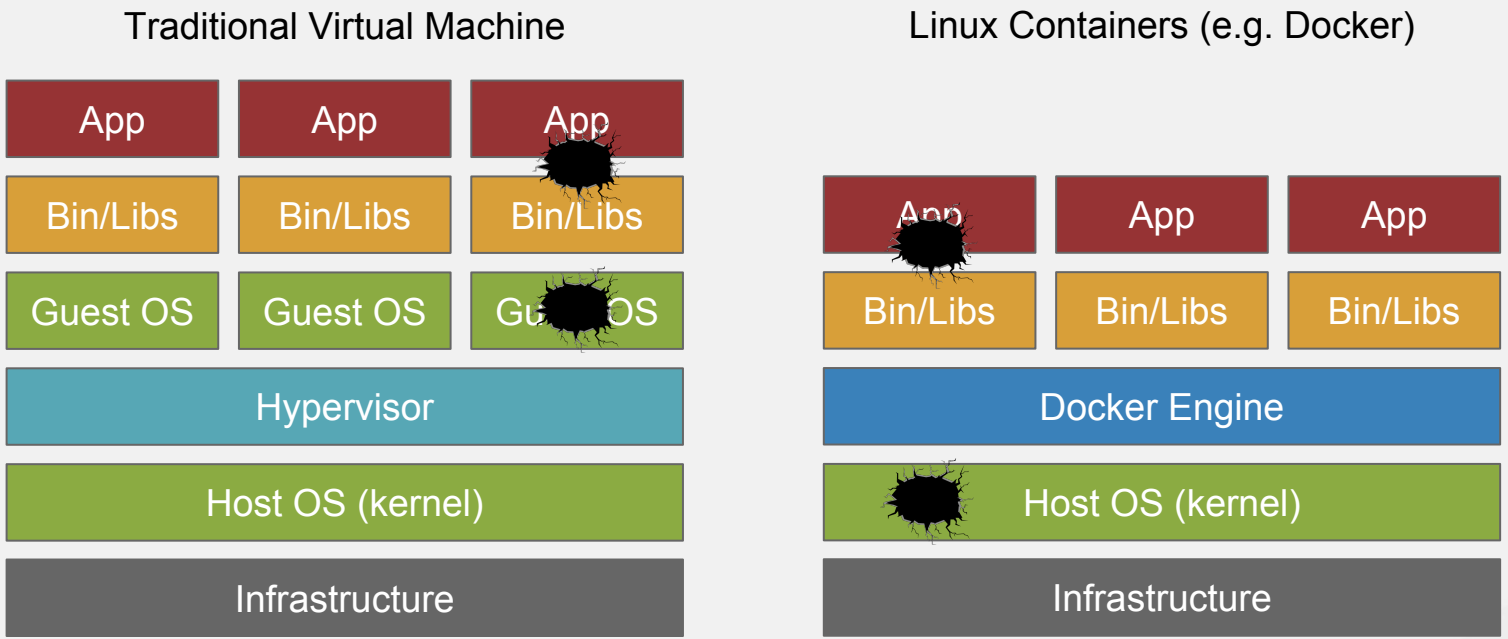
Containers and images

- Container
  - Process isolated by Linux kernel features
  - Virtualization technology
- Image
  - Static container used to run containers
- Container is an instance of a (container) image

Container is not a virtual machine



Container is not a virtual machine



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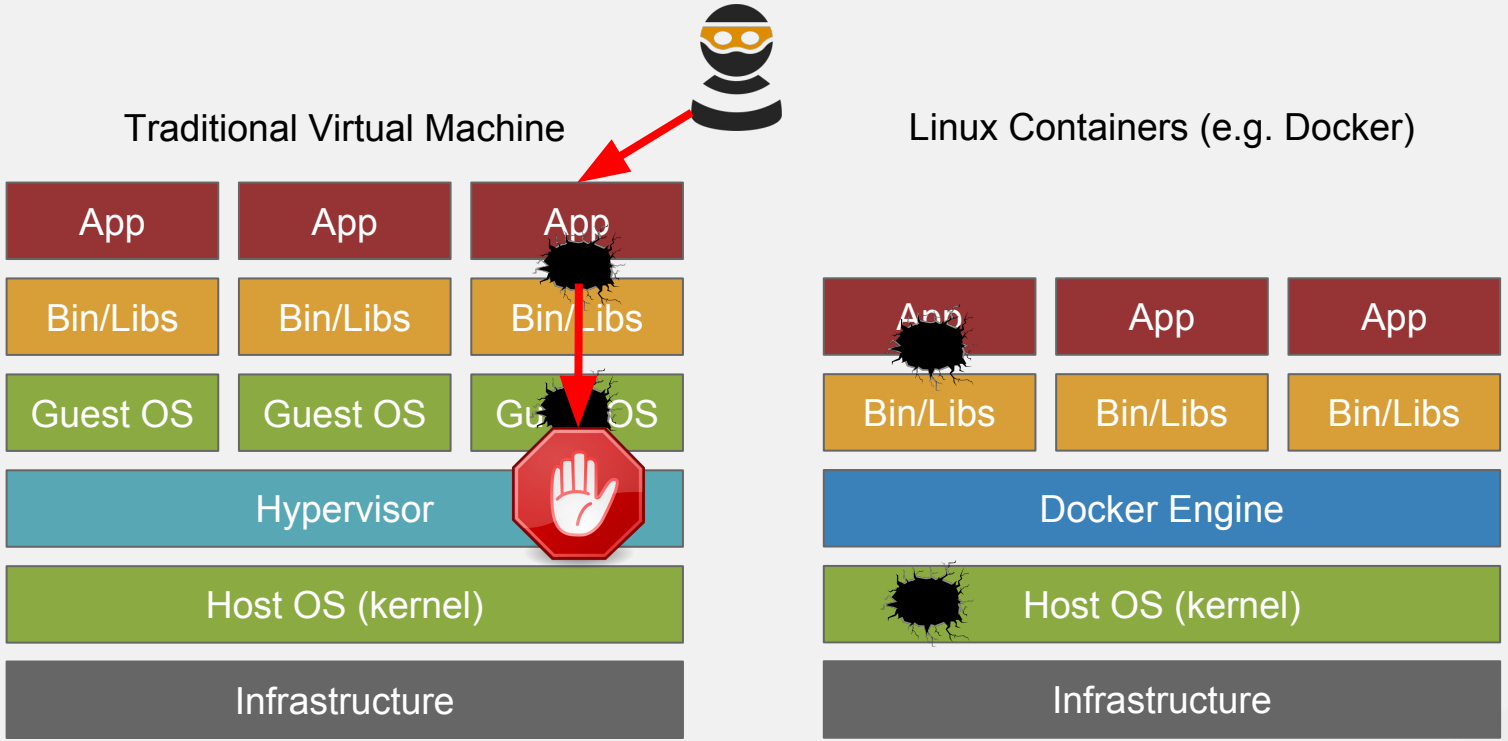

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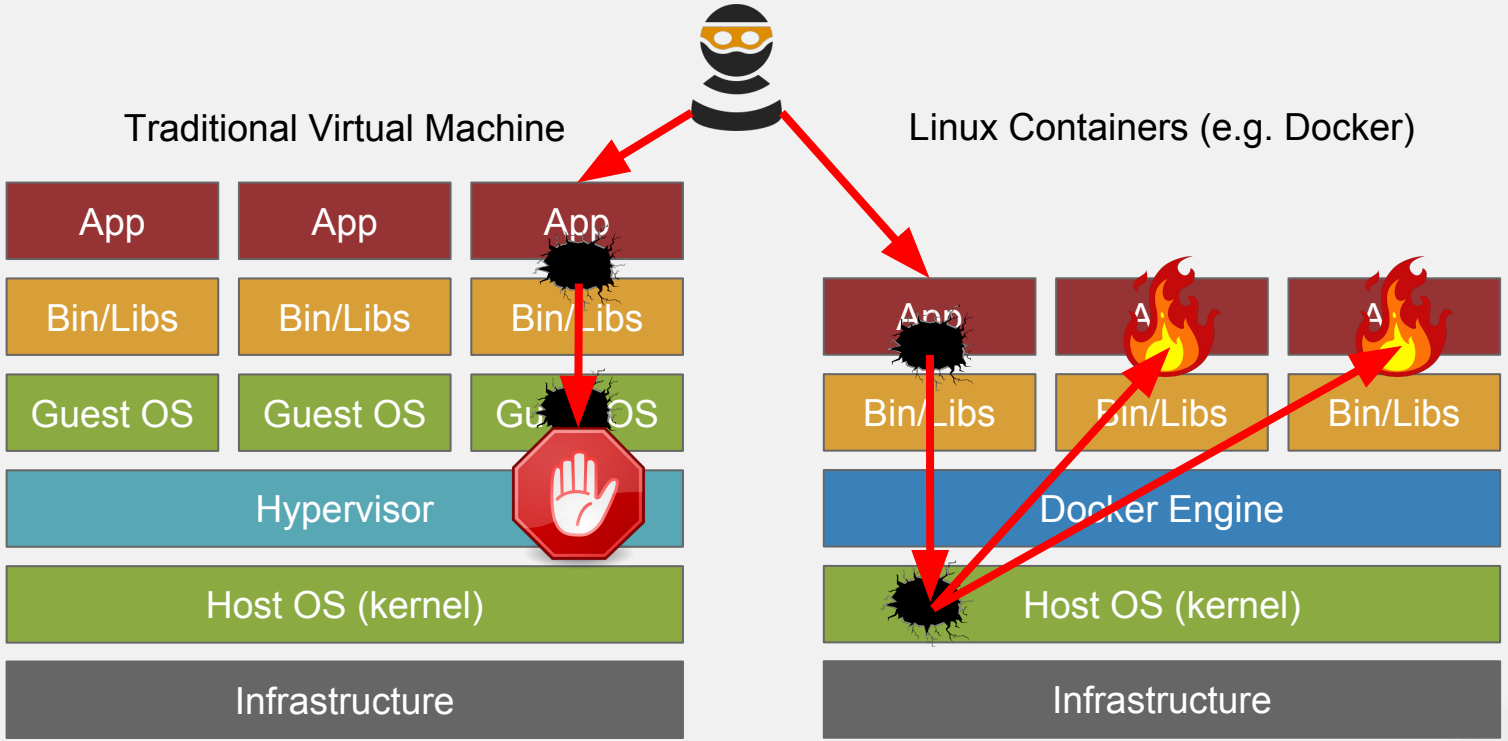

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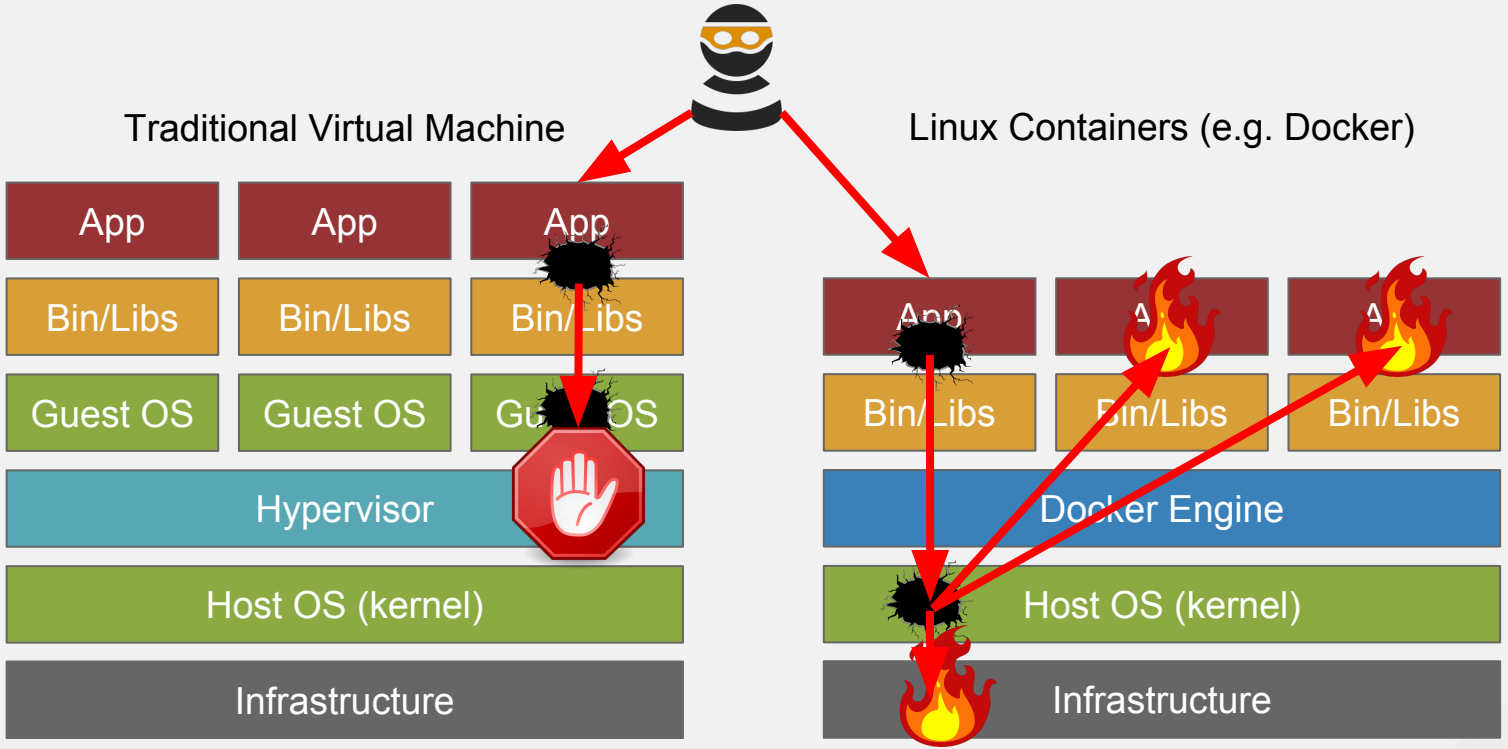


Use only content you trust.

It is sitting in the corner, it is green and very dangerous.
What is it?

Avoid root inside container or use user namespaces.

2. WHY CONTAINERS MATTER?

Containers gain popularity

- New kernel features (namespaces, cgroups, ...)
- Clouds love containers
- Easy app installation on Android
- Docker introduced simple packaging format
- DevOps
- Kubernetes (k8s)
    - open source container cluster manager

3. POSTGRESQL DOCKER CONTAINER

Installing RPMs in container

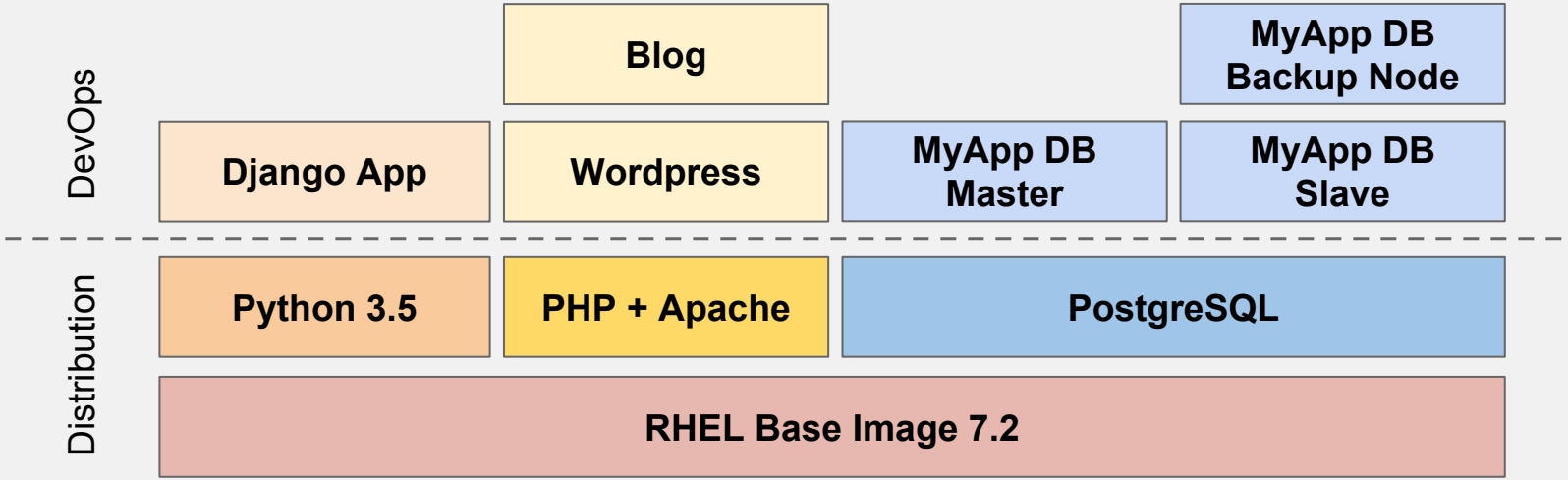
```
#> cat Dockerfile
FROM rhel7:7.2
RUN yum -y install postgresql-server && \
    yum clean all

#> docker build .
```

Installing RPMs in container

```
#> docker build .
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM rhel7:7.2
 ---> c453594215e4

...

Installed:
  postgresql-server.x86_64 0:9.2.15-1.el7_2

Dependency Installed:
  postgresql.x86_64 0:9.2.15-1.el7_2    postgresql-libs.x86_64 0:9.2.15-1.el7_2
  systemd-sysv.x86_64 0:219-19.el7_2.9

Complete!
 ---> 1ff2f2d0bc66
Removing intermediate container 2a86d8a78b75
Successfully built 1ff2f2d0bc66
```

Docker and Layers

What is gonna be part of distribution and what is beyond.



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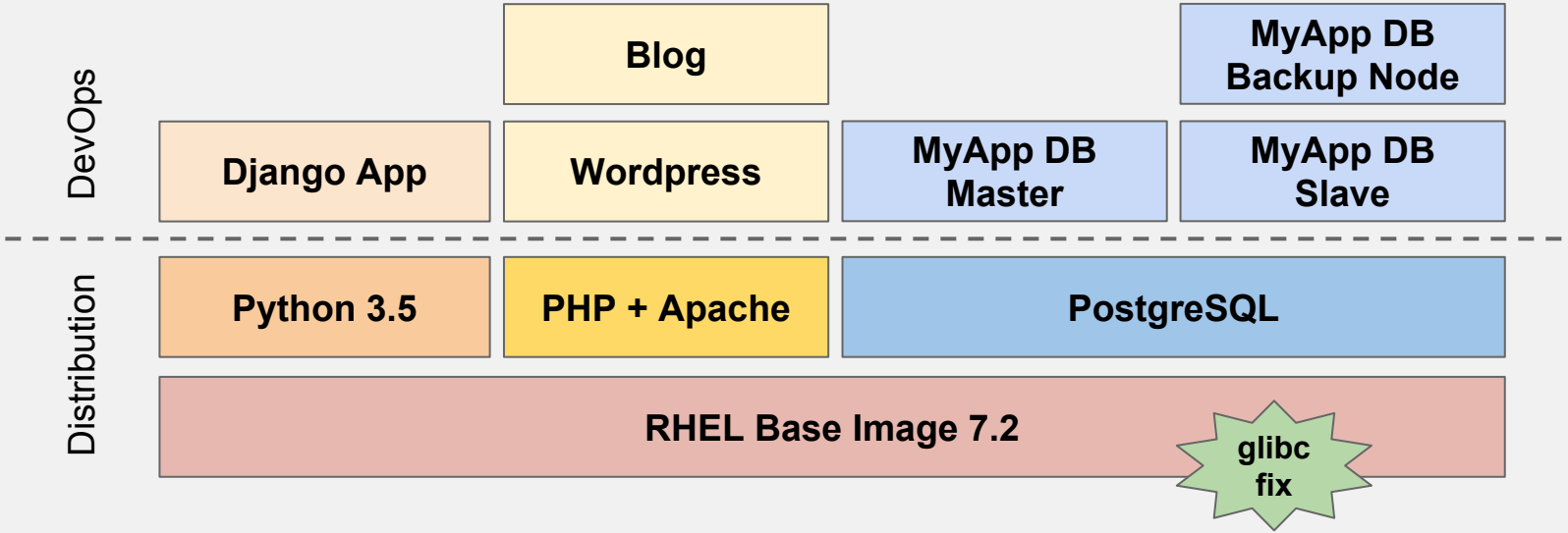

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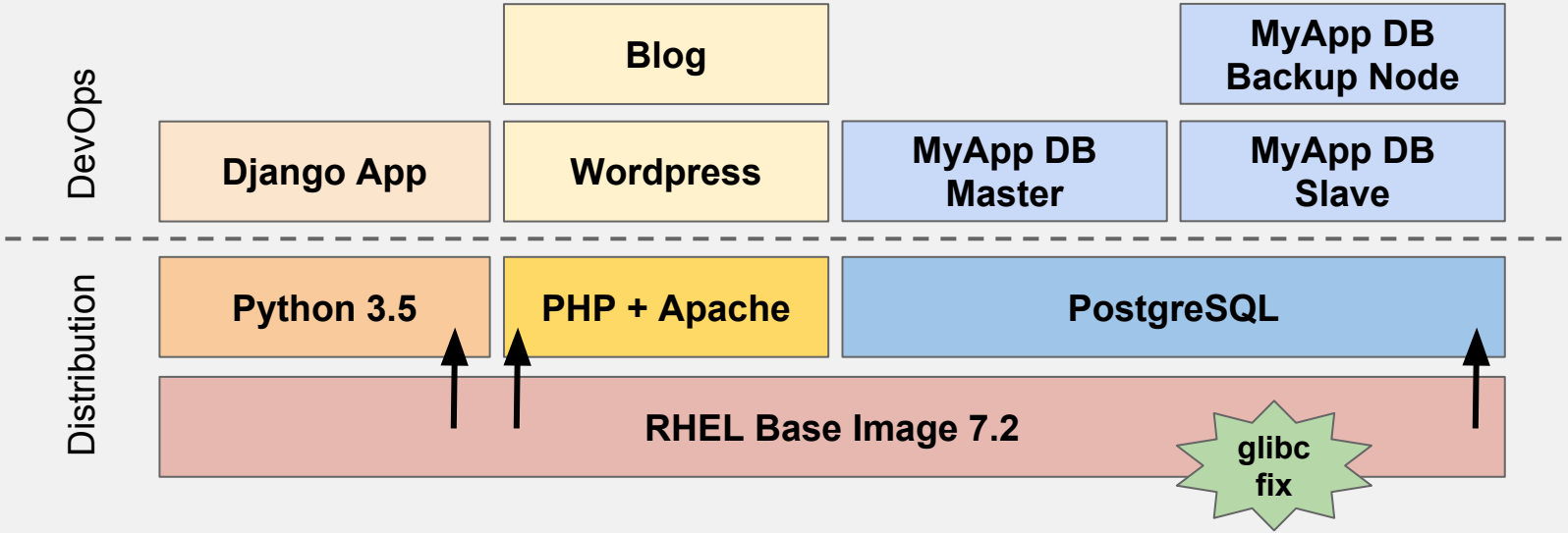

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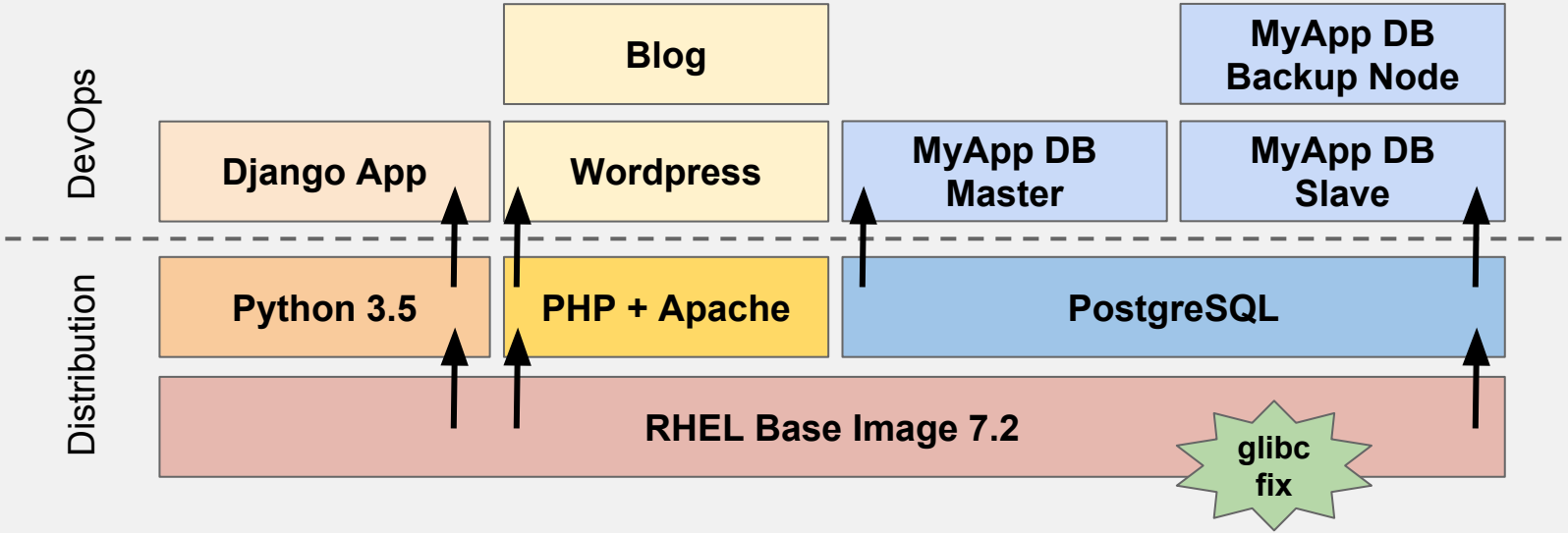

Docker and Layers

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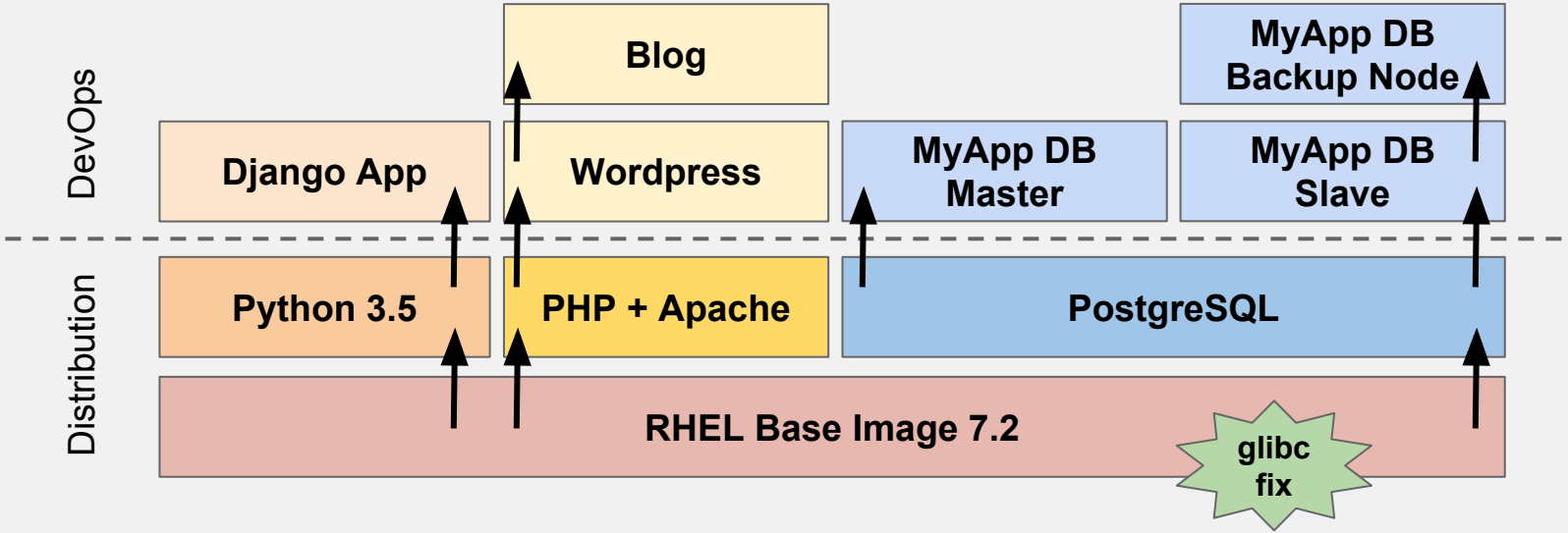


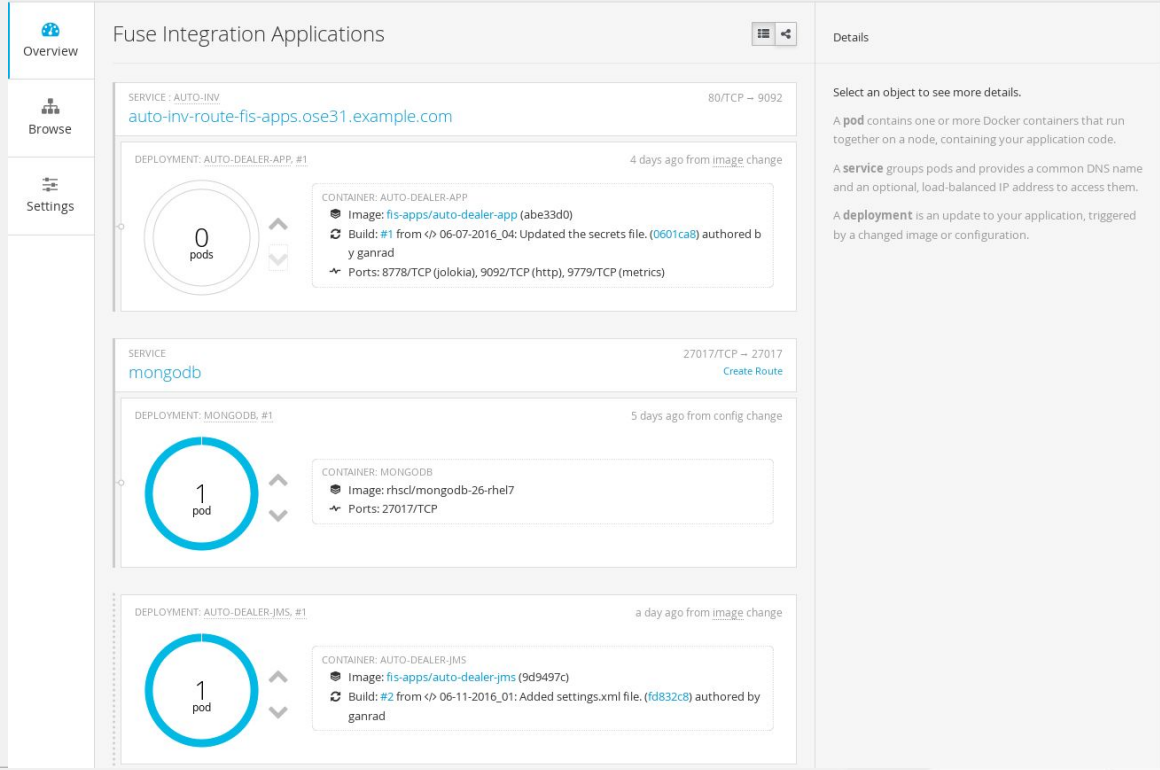
Automate.

Automate.
Everything.

Containers in Red Hat

...end in OpenShift

- PaaS on top of k8s
- Building included
- Whole app lifecycle
- Aims on DevOps
- It scales!
- OpenShift v3.3 GA



https://blog.openshift.com/red-hat-container-platform-3-3-general-availability/

Correct RPMs are in a container

```
#> docker build -t hhorak/postgresql .
…

#> docker run -ti hhorak/postgresql
bash-4.2$ rpm -q postgresql-server
postgresql-server-9.2.15-1.el7_2.x86_64
```

So we have PostgreSQL in a Linux container.
Are we there yet?

Make container do something

```
#> cat Dockerfile

FROM rhel7:7.2

RUN yum -y install postgresql-server && yum clean all

ENV HOME=/var/lib/pgsql
ENV PGDATA=/var/lib/pgsql/data
ENV PGUSER=postgres
USER 26

ADD run-postgresql /usr/bin/
CMD [ "/usr/bin/run-postgresql" ]
```

Make container do something

Who said microservice?

```
#> cat run-postgresql

#!/bin/bash

initdb

echo "host all all 0.0.0.0/0 md5" >${PGDATA}/pg_hba.conf
echo "listen_addresses = '*'" >${PGDATA}/postgresql.conf

exec postgres "$@"
```

Connecting to PostgreSQL container

```
#> docker run -ti -p 5432:5432 --name p1 postgresql

#> docker inspect --format='{{.NetworkSettings.IPAddress}}' p1
172.17.0.2

#> psql -h 172.17.0.2
Password: _
```

Connecting to PostgreSQL container

```
#> docker run -ti -p 5432:5432 --name p1 postgresql

#> docker inspect --format='{{.NetworkSettings.IPAddress}}' p1
172.17.0.2

#> psql -h 172.17.0.2
Password: _
```

Do not use default passwords.

Connecting to PostgreSQL container

```
#> cat run-postgresql

...
echo "host all all 0.0.0.0/0 md5" >${PGDATA}/pg_hba.conf
echo "local all postgres peer" >>${PGDATA}/pg_hba.conf
echo "listen_addresses = '*'" >${PGDATA}/postgresql.conf

pg_ctl -w start -o "-h ''"
psql --command "ALTER USER \"postgres\" WITH ENCRYPTED PASSWORD
'${POSTGRESQL_ADMIN_PASSWORD}';"
pg_ctl stop

exec postgres "$@"
```

Connecting to PostgreSQL container

```
#> docker run -ti -d -p 5432:5432 --name p1 \
              -e POSTGRESQL_ADMIN_PASSWORD=pass postgresql
b1e23c844346d2788d7b7891d8f78244788f71b19dcf291b05cdf1d7685ef556

#> psql -h 172.17.0.2 -U postgres
Password for user postgres:
psql (9.2.15, server 9.2.15)
Type "help" for help.

postgres=# _
```

Or use k8s secrets

http://kubernetes.io/docs/user-guide/secrets/

```
if [ -e "/run/secrets/pgusers/user/username" ] ; then
  POSTGRESQL_USER="$(</run/secrets/pgusers/user/username)"
  POSTGRESQL_PASSWORD="$(</run/secrets/pgusers/user/password)"
fi
```

How to configure such a database?

Configuring PostgreSQL container

```
#> cat run-postgresql
...
echo "max_connections = ${POSTGRESQL_MAX_CONNECTIONS}"
>>${PGDATA}/postgresql.conf
...
```

Example of PostgreSQL 9.5 container

```
#> docker run -d \
          -p 5432:5432 \
          -e POSTGRESQL_ADMIN_PASSWORD=secret \
          -e POSTGRESQL_MAX_CONNECTIONS=10 \
          -e POSTGRESQL_USER=guestbook \
          -e POSTGRESQL_PASSWORD=pass \
          -e POSTGRESQL_DATABASE=guestbook \
          -v /db:/var/lib/pgsql/data:Z \
          rhscl/postgresql-95-rhel7
```

Support the most common configuration (let users to change them in OpenShift) and allow users to build their own specific layered container images easily.

How?

Extending PostgreSQL container

```
#> cat Dockerfile
FROM rhscl/postgresql-95-rhel7
COPY post-init-hooks ${CONTAINER_SCRIPTS_PATH}/hooks.d

#> cat post-init-hooks/post-init
echo max_wal_senders=10" >> "${POSTGRESQL_CONFIG_FILE}"
echo "lock_timeout=${POSTGRESQL_LOCK_TIMEOUT}" >>
"${POSTGRESQL_CONFIG_FILE}"
psql -f initdb.sql

#> docker build -t hhorak/postgresql-95-rhel7 .
```

Extending PostgreSQL container

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FROM rhscl/postgresql-95-rhel7
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echo max_wal_senders=10" >> "${POSTGRESQL_CONFIG_FILE}"
echo "lock_timeout=${POSTGRESQL_LOCK_TIMEOUT}" >>
"${POSTGRESQL_CONFIG_FILE}"
psql -f initdb.sql

#> docker build -t hhorak/postgresql-95-rhel7 .
```

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#> docker build -t hhorak/postgresql-95-rhel7 .
```

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"${POSTGRESQL_CONFIG_FILE}"
psql -f initdb.sql

#> docker build -t hhorak/postgresql-95-rhel7 .
```

Extending PostgreSQL container

```
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COPY post-init-hooks ${CONTAINER_SCRIPTS_PATH}/hooks.d

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echo max_wal_senders=10" >> "${POSTGRESQL_CONFIG_FILE}"
echo "lock_timeout=${POSTGRESQL_LOCK_TIMEOUT}" >>
"${POSTGRESQL_CONFIG_FILE}"
psql -f initdb.sql

#> docker build -t hhorak/postgresql-95-rhel7 .
```

So we build micro-services that will be run in OpenShift.

So we build micro-services that will be run in OpenShift.
OpenShift likes scaling.

So we build micro-services that will be run in OpenShift.
OpenShift likes scaling.
How to make databases to scale?

Scalable PostgreSQL container

```
$ docker run -d --name pg_master
        -e POSTGRESQL_ADMIN_PASSWORD=pass
        -e POSTGRESQL_MASTER_USER=user
        -e POSTGRESQL_MASTER_PASSWORD=pass
        -p 5432:5432 rhscl/postgresql-95-rhel7
        run-postgresql-master

$ docker run -d --name pg_master
        -e POSTGRESQL_ADMIN_PASSWORD=pass
        -e POSTGRESQL_MASTER_USER=user
        -e POSTGRESQL_MASTER_PASSWORD=pass
        -p 5432:5432 rhscl/postgresql-95-rhel7
        -e POSTGRESQL_MASTER_IP=172.16.12.2
        run-postgresql-slave
```

Scalable PostgreSQL container

```
$ docker run -d --name pg_master
        -e POSTGRESQL_ADMIN_PASSWORD=pass
        -e POSTGRESQL_MASTER_USER=user
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        -p 5432:5432 rhscl/postgresql-95-rhel7
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```

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        -p 5432:5432 rhscl/postgresql-95-rhel7
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```

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        -p 5432:5432 rhscl/postgresql-95-rhel7
        run-postgresql-master

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        -e POSTGRESQL_MASTER_USER=user
        -e POSTGRESQL_MASTER_PASSWORD=pass
        -p 5432:5432 rhscl/postgresql-95-rhel7
        -e POSTGRESQL_MASTER_IP=172.16.12.2
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```

Scalable PostgreSQL container

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         -e POSTGRESQL_MASTER_USER=user
         -e POSTGRESQL_MASTER_PASSWORD=pass
         -p 5432:5432 rhscl/postgresql-95-rhel7
         run-postgresql-master

$ docker run -d --name pg_master
         -e POSTGRESQL_ADMIN_PASSWORD=pass
         -e POSTGRESQL_MASTER_USER=user
         -e POSTGRESQL_MASTER_PASSWORD=pass
         -p 5432:5432 rhscl/postgresql-95-rhel7
         -e POSTGRESQL_MASTER_IP=172.16.12.2
         run-postgresql-slave
```

For more complex replication users are expected to build own layer.

Auto-tuning in PostgreSQL container

Containers may be slim or fat.

```
# Get available memory for container
MEMORY_IN_BYTES=$(cat /sys/fs/cgroup/memory/memory.limit_in_bytes)

# Use 1/4 of given memory for shared buffers
POSTGRESQL_SHARED_BUFFERS="$(($MEMORY_IN_BYTES/1024/1024/4))MB"

# Setting effective_cache_size to 1/2 of total memory
POSTGRESQL_EFFECTIVE_CACHE_SIZE="$(($MEMORY_IN_BYTES/1024/1024/2))MB"

# postgresql.conf is later generated as:
shared_buffers = ${POSTGRESQL_SHARED_BUFFERS}
effective_cache_size = ${POSTGRESQL_EFFECTIVE_CACHE_SIZE}
```

For working code, see:
https://github.com/sclorg/postgresql-container

Or play with container directly

```
#> docker pull centos/postgresql-94-centos7
#> docker pull centos/postgresql-95-centos7

#> docker pull registry.access.redhat.com/rhscl/postgresql-94-rhel7
#> docker pull registry.access.redhat.com/rhscl/postgresql-95-rhel7
```

4. SYSTEM CONTAINERS

Run container as systemd service

i.e. replace daemon with container

We need to:

1. Create Docker container
2. Create systemd unit file for the service
3. Work with the systemd unit as usually

Run container as systemd service

1. Create Docker container (but not run)

```
#> docker create
          --name postgresql-service
          -e …
          -v /var/lib/pgsql:/var/lib/pgsql:Z
          fedora/postgresql
```

Run container as systemd service

2. Create systemd unit file for the service

```
# cat /etc/systemd/system/postgresql-cont.service
[Unit]
Description=PostgreSQL service as a docker container
After=docker.service

[Service]
ExecStart=/usr/bin/docker start postgresql-cont
ExecStop=/usr/bin/docker stop postgresql-cont

[Install]
WantedBy=multi-user.target
```

Run container as systemd service

3. Work with the systemd service as usually

```
#> systemctl enable postgresql-cont.service
#> systemctl start postgresql-cont.service
```

Not every container is a daemon

5. TOOLS CONTAINERS

Tools to manage daemons

(that are not part of the daemon image)

```
#> docker run -ti hhorak/postgresql-tools pgbench ...

#> docker run -ti hhorak/postgresql-tools pg_standby ...
```

Interaction is easy, we can use network socket to work with daemon.

How to interact with host

```
#> docker exec -ti postgresql1 pg_dump >/home/hhorak/dump.sql

#> docker run -ti -v /:/host hhorak/postgresql bash
bash-4.2$ pg_dump >/host/home/hhorak/dump.sql
bash-4.2$ ...
```

6. GUI APPS IN CONTAINERS

Why GUI in containers

- Some level of isolation
  - Filesystem, Cgroups, Namespaces
- Deps bundling ➜one app running on any Linux
- Android-like app store for all distros
- Clean system underneath

GUI in Docker

Well, it sometimes even works, but..

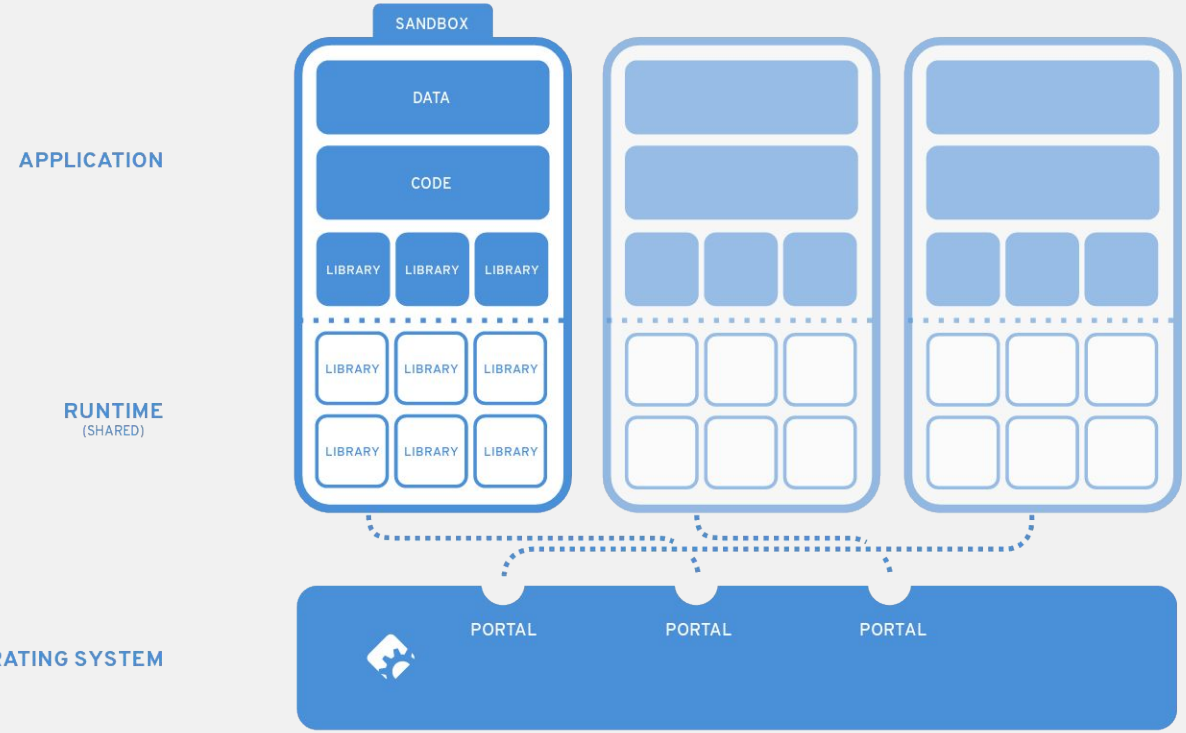
```
docker run -ti --rm \
       -e DISPLAY=$DISPLAY \
       -v /tmp/.X11-unix:/tmp/.X11-unix \
       -u 1001 \
       hhorak/pgadmin3
```

GUI in Flatpak

aka xdg-app

- Designed for GUI apps
- Sandbox rather than full container
- Runtimes define common environment to build on
- Runs in desktop session

Flatpak design



http://flatpak.org/#developers

Working with Flatpak application

http://flatpak.org/developer.html

```
$ tar xvf pgadmin3-1.22.1.tar.gz
$ cd pgadmin3-1.22.1

$ flatpak build ../dictionary ./configure --prefix=/app
$ flatpak build ../dictionary make
$ flatpak build ../dictionary make install
```

```
$ flatpak install gnome org.gnome.Platform 3.20
$ flatpak install gnome-apps org.postgresql.pgadmin3 stable

$ flatpak run org.postgresql.pgadmin3
```

7. OS CONTAINERS

MultiContainer vs. OS Container

vs

Operating System Container

Running whole OS (systemd or other init process) inside container.

- Some applications work better when running on one machine
- Handy for transition period
  - Part of the services as containers, rest as standard services
- Safe zombie handling
- Container’s journald integration

Running systemd inside Docker

http://developers.redhat.com/blog/2016/09/13/running-systemd-in-a-non-privileged-container

```
docker run -ti --tmpfs /run --tmpfs /tmp
           -v /sys/fs/cgroup:/sys/fs/cgroup:ro <your-image>
```

```
FROM fedora:24
RUN dnf -y install postgresql-server; dnf clean all
RUN systemctl enable postgresql
STOPSIGNAL SIGRTMIN+3
EXPOSE 80
CMD [ "/sbin/init" ]
```

OS Container using systemd-nspawn

Running whole OS (including systemd) inside container.

- better connection with host (logging, machinectl, ...)
- no image management, no containers linking
- good enough for testing or debugging something at container level

Running systemd inside nspawn

https://www.variantweb.net/blog/using-systemd-nspwan-for-lightweight-container-in-fedora-21/

```
dnf -y --releasever=24 --nogpg --installroot=/var/tmp/testnspawn
    --disablerepo='*' --enablerepo=fedora --enablerepo=updates install
systemd passwd yum fedora-release postgresql-server @standard
chcon -R -t svirt_sandbox_file_t /var/tmp/testnspawn
restorecon -R /var/tmp/testnspawn
```

```
systemd-nspawn -D /var/tmp/testnspawn
passwd
postgresql-setup --init
systemctl enable postgresql
```

```
systemd-nspawn -bD /var/tmp/testnspawn
```

Who likes Ansible?

8. Ansible containers

Ansible containers

- Building containers using popular Ansible
- Orchestrating containers like other services
- Especially useful for transition to containers

Ansible Container

https://github.com/ansible/ansible-container-examples/tree/master/wordpress

```
services:
  db:
    image: rhel:7
    ports:
      - "5432:5432"
    command: ['/usr/bin/pg_ctl', '-w', 'start']

  wordpress:
    image: rhel:7
    ports:
      - "80:80"
    links:
      - db
command: bash -c "bash /tmp/a.sh ; usr/sbin/apachectl -D FOREGROUND"
```

Ansible container

```
- hosts: db
  vars:
    - wp_pgsql_db: wordpress
    - wp_pgsql_user: wordpress
    - wp_pgsql_password: password
  tasks:
    - name: Install postgresql-server
      yum:
        name: "{{ item }}"
        state: latest
      with_items:
        - postgresql-server

    - name: Update the repository
      shell: yum -y erase vim-minimal && \
             yum -y update && \
             yum clean all
```

```
    - name: postgresql-init
      shell: postgresql-setup --upgrade

    - name: run postgres
      shell: pg_ctl -w start

    - name: Create postgres database
      pgsql_db:
        name: "{{ wp_pgsql_db }}"
        state: present

    - name: Create postgres user
      pgsql_user:
        name: "{{ wp_pgsql_user }}"
        password: "{{ wp_pgsql_password }}"
        state: present
        priv: "*.*:ALL,GRANT"
        host: "%"
```

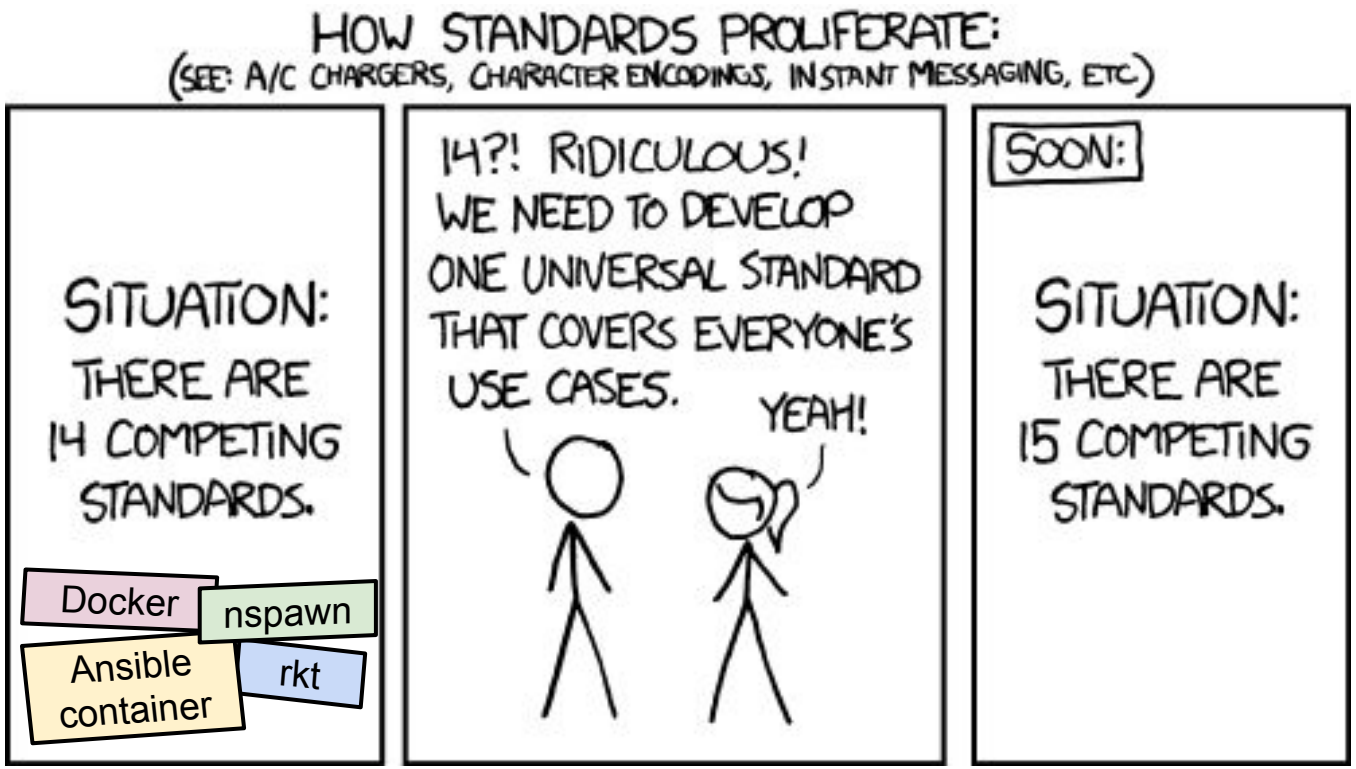
Ansible Container

https://github.com/ansible/ansible-container-examples/tree/master/wordpress

```
$> ansible-container init
 -- do changes --
$> ansible-container build
$> ansible-container run
$> docker login
$> ansible-container push
$> ansible-container shipit openshift
```

9. OCI

9. OCI
Open Container Initiative


HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)
SITUATION:
THERE ARE
14 COMPETING
STANDARDS.
Docker
nspawn
Ansible container
rkt
14?! RIDICULOUS!
WE NEED TO DEVELOP
ONE UNIVERSAL STANDARD
THAT COVERS EVERYONE'S
USE CASES.
YEAH!
SOON:
SITUATION:
THERE ARE
15 COMPETING
STANDARDS.

"The mission of the OCI is to promote and promulgate a set of common, minimal, open standards and specifications around container technology."

https://www.opencontainers.org

Open Container Initiative

Collaboration of Red Hat, Google, Docker, and others big players in containers world.

- libcontainer - https://github.com/docker/libcontainer
- runc - https://github.com/opencontainers/runc
- Open Container Format

DevConf.cz
Brno, Czech Republic
January 27 - 29, 2017

#DEFINEfuture

A free annual community conference for developers, admins, and users of Linux & JBoss.

redhat.

Thanks.

OpenShift: https://docs.openshift.com
Sources of Docker images: https://github.com/sclorg/
Project Atomic: https://www.projectatomic.io

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Do not forget, content does matter.

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https://hhorak.fedorapeople.org/2016/161031_pgconf_databases_containers.pdf