Containers and Orchestration in the CERN Cloud

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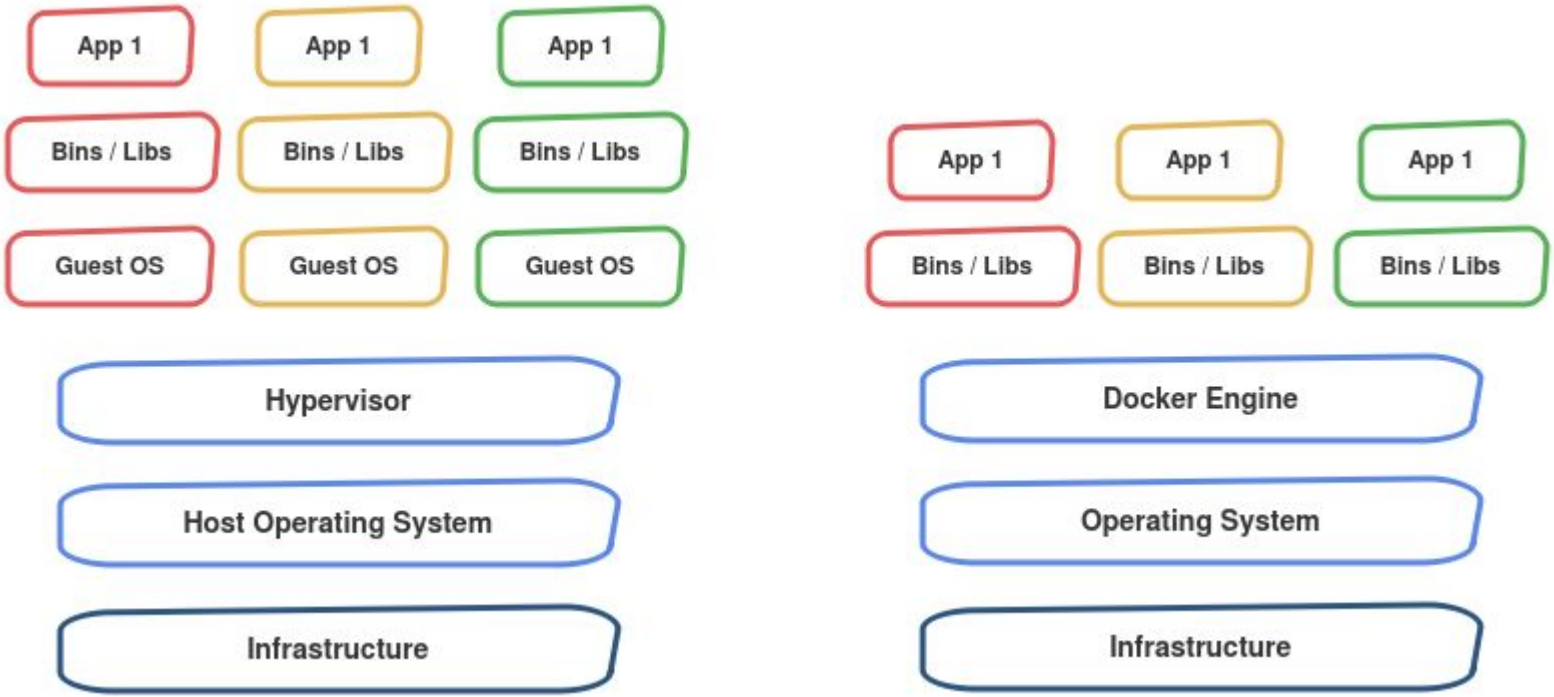
Outline

- Goals
- Containers and Orchestration (Swarm, Kubernetes)
- OpenStack Magnum
- Use Cases
- Demos
- Status and Future Plans

Goals

- Integrate containers with OpenStack at CERN
  - Common Identity, Resource allocation, Networking, Data Access, ...
- Container orchestration agnostic
  - Support for Docker Swarm, Kubernetes, Mesos, …
- Fast and easy to use
  - Quick launch, easy scaling of clusters

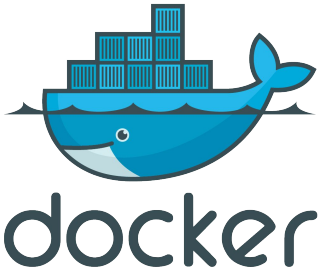
Container Overview

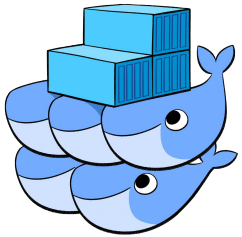


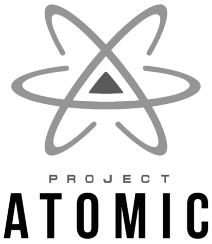
Container Overview

- Process isolation - kernel namespaces & cgroups
- Same kernel, improved performance
- Microservices
- Images repository
  - dockerhub
  - private repos: docker.cern.ch pilot from Linux team

Container Orchestration



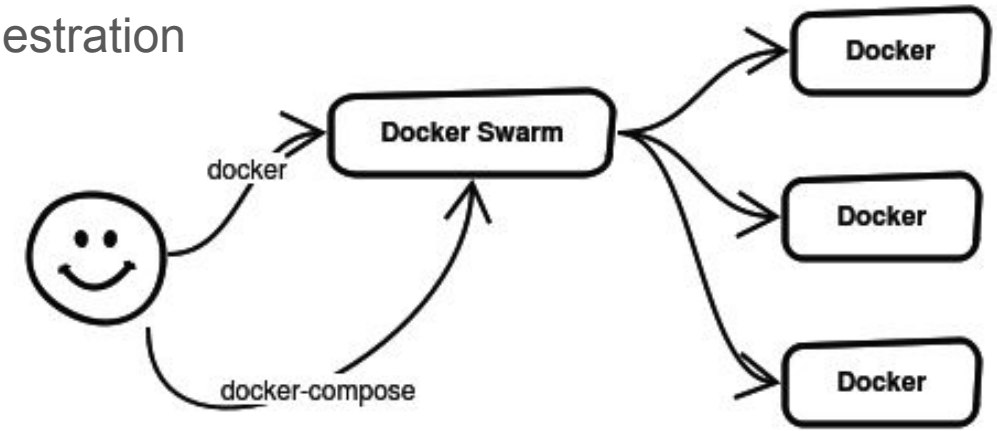




And a loooot more...

Docker Swarm / Compose

- Clustering of Docker nodes
- Native Docker API
- Docker Compose for orchestration



- If it works with Docker, it works with Swarm!

Docker Swarm: uses the docker client

```
docker info
Containers: 3
...
Nodes: 2

docker run -d nginx
7100f1bc8619580a8b9e70bb5c12e60a4bd7e543f189e26018ef1924fd641a0a

docker ps
7100f1bc8619        nginx                          "nginx -g 'daemon off"   18 seconds ago      Up 9 seconds
80/tcp, 443/tcp

docker run -it centos:7 /bin/bash
[root@1836f9c42754 /]#
```

Docker Swarm: advanced features

- Scheduler filters
  - Node filters - where should my container run (SSDs or not? Storage driver?)
  - Container filters - affinities, dependencies, ports, etc
- Labels
  - Tag a node with a label (docker daemon config)
  - Tag a container with a label
  - Use labels later for scheduling
  - Examples: production vs dev, fast vs slow storage

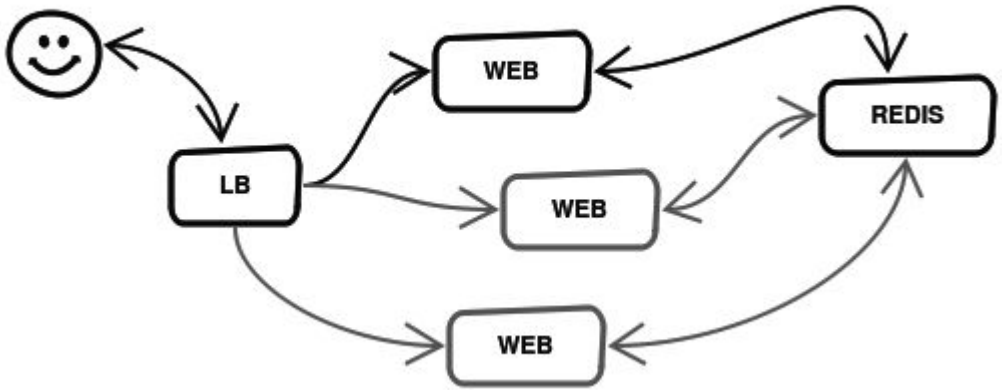
docker run … -e affinity:container==frontend -e constraint:storage==ssd

Docker Compose

- Container orchestration
- Easy way to define a full application stack in one file
  - Networks
  - Containers
  - Affinities
  - Exposed ports
  - …
- Additional features to scale applications, access logs, ...

Docker Compose

```
lb:
  image: docker.io/tutum/haproxy
  ports:
    - 80:80
  links:
    - web
web:
  image: docker.io/rochaporto/python-redis
  expose:
   - 5000
  links:
   - redis
redis:
  image: docker.io/redis
```

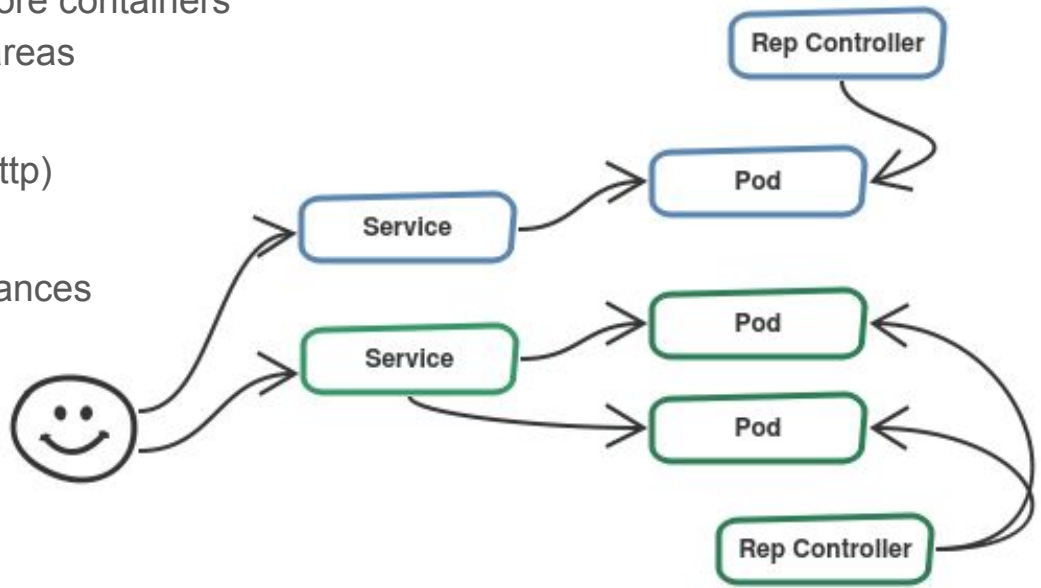


docker-compose up

docker-compose scale web=3

Kubernetes

- Container orchestration with some more advanced concepts
- Pod
  - Unit of deployment, one or more containers
  - Sharing network, filesystem areas
- Service
  - Entrypoint to a service (tcp, http)
- Replication Controller
  - Manages number of Pod instances
  - Scaling
- Auto scaling policies



Kubernetes

```
apiVersion: v1
kind: ReplicationController
metadata:
  name: redis-controller
spec:
  replicas: 1
  selector:
    app: redis
  template:
    metadata:
      labels:
        app: redis
    spec:
      imagePullPolicy: Always
      containers:
      - name: redis
        image: redis
        ports:
        - containerPort: 6379
```

```
apiVersion: v1
kind: ReplicationController
metadata:
  name: web-controller
spec:
  replicas: 1
  selector:
    app: web
  template:
    metadata:
      labels:
        app: web
    spec:
      imagePullPolicy: Always
      containers:
      - name: web
        image: docker.io/rochaporto/python-redis
        env:
        - name: REDIS_HOSTNAME
          value: 10.254.13.13
        ports:
        - containerPort: 5000
```

Kubernetes

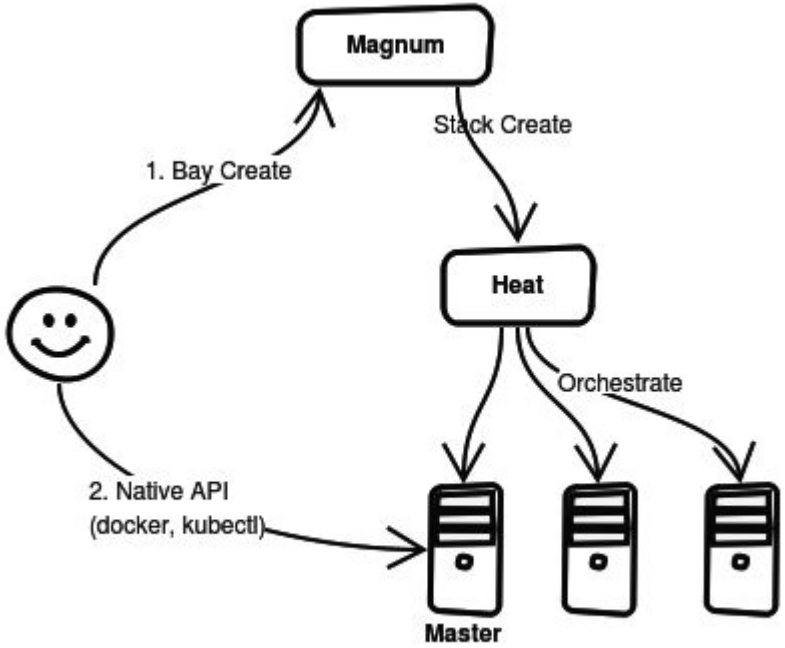
```
kubectl create -f stack.yaml

kubectl get pods
NAME                     READY     STATUS    RESTARTS   AGE
redis-controller-u0b3m   1/1       Running   0          1m
web-controller-r2d8z     1/1       Pending   0          1m

kubectl scale --replicas=3 rc web-controller
scaled

kubectl get pods
NAME                     READY     STATUS    RESTARTS   AGE
redis-controller-u0b3m   1/1       Running   0          10m
web-controller-0ya1w     1/1       Running   0          10s
web-controller-4qhzj     1/1       Running   0          10s
web-controller-r2d8z     1/1       Running   0          10m
```

Comparison

	Docker Swarm / Compose	Kubernetes
Docker API	Yes	No
Expose Port	Yes	Yes
Load Balancing	No	Yes
Failover	Experimental	Yes
Node Scaling	Yes	Yes
Container Scaling	Manual	Auto
Cluster Network	Yes	Yes

OpenStack Magnum

- Container orchestration (COE) as first class resources in OpenStack
- Easy orchestration of container clusters
- Support multiple container engines
  - Swarm, Kubernetes, Mesos
- Native COE API access
  - Hard to abstract 100% functionality
- Higher level abstractions when possible
  - Like container-create, unclear if it will stay



OpenStack Magnum Concepts

NODE

A physical node or a virtual machine

Runs one or more containers

BAY MODEL

A description of a container cluster

Which node flavor, image, network to use

Which container orchestrator engine (COE)

BAY

A container cluster

Based on a bay model

Additional properties like name, number of nodes, number of masters

Can be scaled (number of nodes)

CONTAINER

Runs in a specific bay

Not directly launched by Magnum today, use the native API

OpenStack Magnum Usage

```
magnum baymodel-create --name rocha-swarm-model \
    --flavor-id m2.medium \
    --image-id fedora-atomic-23 \
    --keypair-id rocha-cern \
    --external-network-id CERN_NETWORK \
    --dns-nameserver 137.138.17.5 \
    --coe swarm

magnum bay-create --baymodel rocha-swarm-model --node-count 1 --name rocha-swarm-bay01

magnum ca-sign --bay rocha-swarm-bay01 --csr cert.csr > cert.pem
magnum ca-show --bay rocha-swarm-bay01 > ca.pem

magnum bay-show rocha-swarm-bay01 | grep api_address
| api_address        | https://137.138.6.99:2376                                  |

vim env.sh
export DOCKER_CERT_PATH="/home/rocha/bays/rocha-swarm-bay01"
export DOCKER_HOST="tcp://137.138.6.99:2376"
export DOCKER_TLS_VERIFY="true"
```

OpenStack Magnum Usage

docker info

```
Containers: 3
Images: 15
Role: primary
Strategy: spread
Filters: health, port, dependency, affinity, constraint
Nodes: 2
 gi-r-swarm-f23-cl2rjehq46cn-swarm-master-batso7sig26i.novalocal: 137.138.6.99:2375
  └ Status: Healthy
  └ Containers: 3
  └ Reserved CPUs: 0 / 2
  └ Reserved Memory: 0 B / 4.053 GiB
  └ Labels: executiondriver=native-0.2, kernelversion=4.3.3-301.fc23.x86_64, operatingsystem=Fedora 23
(Twenty Three), storagedriver=devicemapper
  └ Error: (none)
  └ UpdatedAt: 2016-02-24T14:04:08Z

...
```

OpenStack Magnum Usage

docker run -d nginx

```
7100f1bc8619580a8b9e70bb5c12e60a4bd7e543f189e26018ef1924fd641a0a
```

docker ps

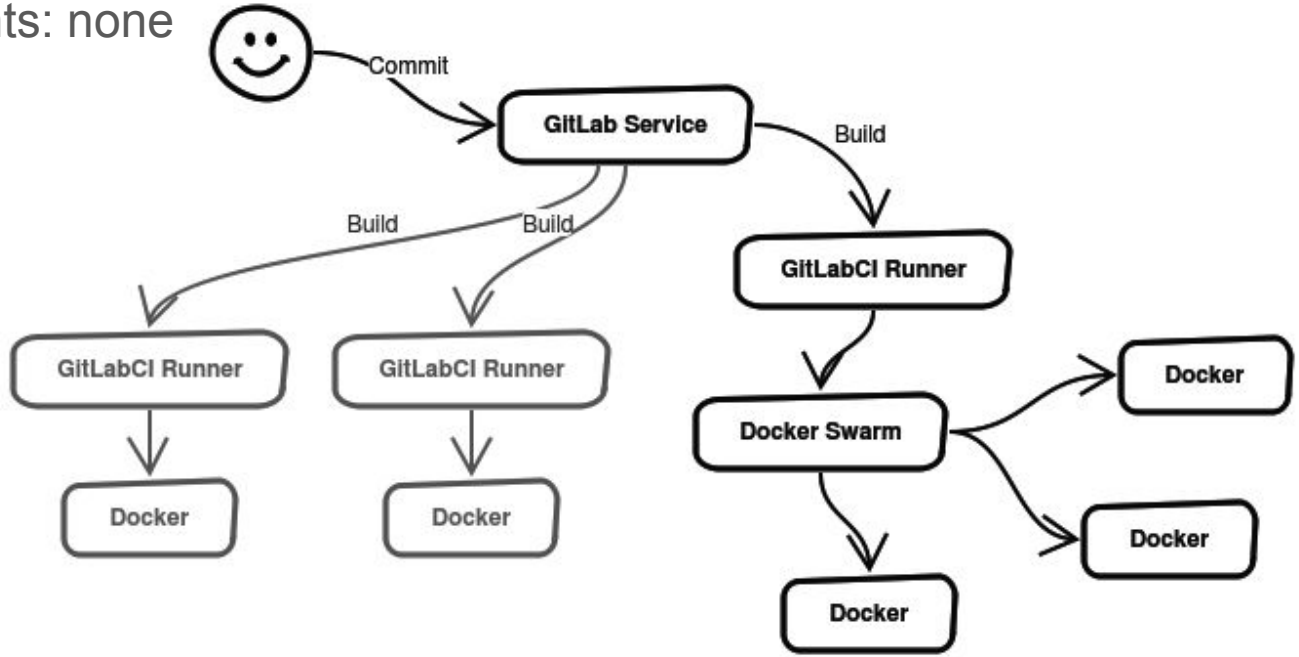
```
CONTAINER ID        IMAGE                          COMMAND                  CREATED             STATUS
PORTS               NAMES
7100f1bc8619        nginx                          "nginx -g 'daemon off"   18 seconds ago      Up 9 seconds
80/tcp, 443/tcp     gi-pmahou2a6o7-0-du6blcrn5x6h-swarm-node-4x5lhufqcya7.novalocal/sad_visvesvaraya
```

magnum bay-update replace node_count=5

Container Use Cases

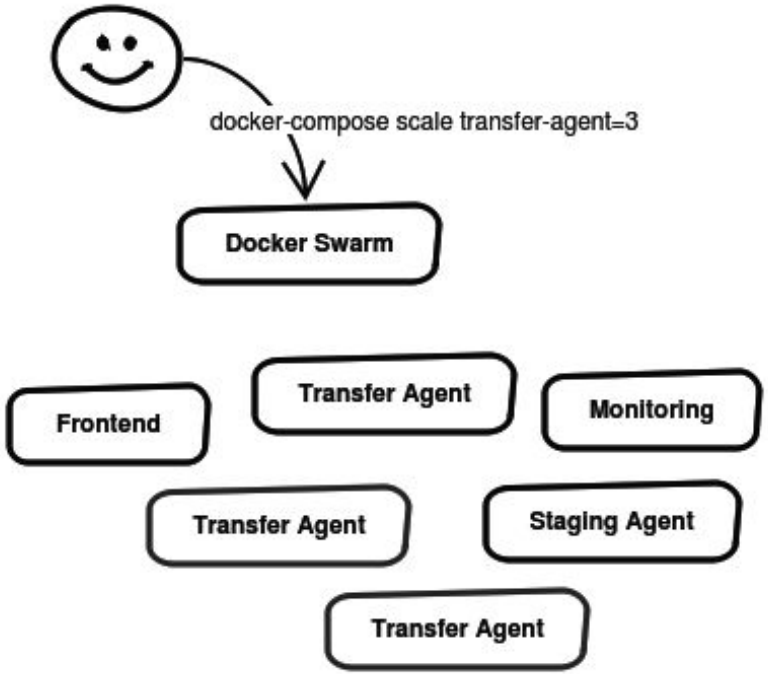
Easy scaling with Swarm: GitLab CI

- Continuous integration in GitLab (for the cloud team)
- gitlab-ci-multi-runner, using the docker executor
- Specific requirements: none



Infrastructure Services - FTS Example

- Currently scaling at node level
  - Frontend
  - Transfer Agent
  - Staging Agent (bringOnline)
  - Monitoring

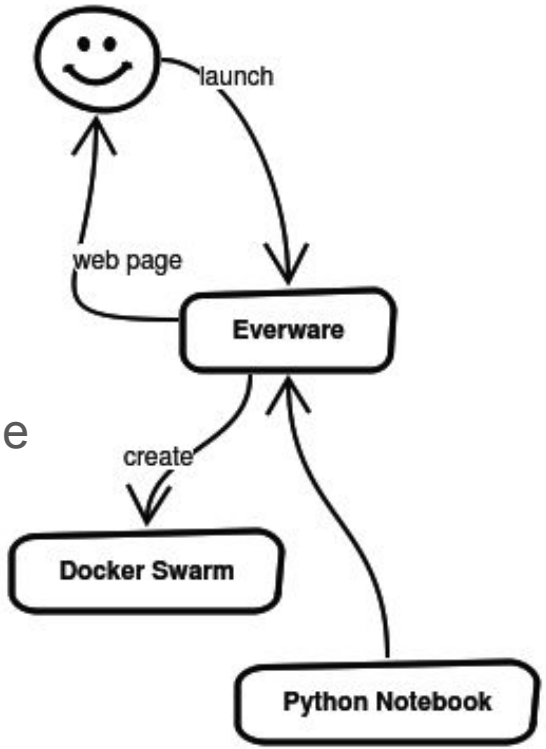


- Scale instead at component level
- Think app component, forget about node
- Specific requirements: AZ awareness

Jupyter Notebooks - End User Analysis

- Everware, Binder, ROOTaaS/Swan, Recast
- Analysis environment at a click of a link
- Jupyter notebooks, web frontend
- Most work with Docker, simply point to Swarm

- Specific requirements: access to the usual storage
  - CVMFS, EOS



Ongoing Work

Integration with CVMFS

- Implemented as a docker volume plugin
  - https://gitlab.cern.ch/cloud-infrastructure/docker-volume-cvmfs
- Manages the CVMFS mounts on request (shared between containers)
- Integrated into Magnum @ CERN

```
magnum baymodel-create --name rocha-bay-model --labels cvmfs=true
```

- Usable with any docker deployment

```
docker volume create -d cvmfs --name atlas.cern.ch

docker run -it --volume-driver cvmfs -v atlas.cern.ch:/atlas centos:7 /bin/bash
```

Persistent storage (via OpenStack Cinder)

- “Attach X GB of persistent storage to Container Z”
  - And reattach later to another, …
- At CERN this means getting a Ceph volume attached to my container
- Code is ready in upstream OpenStack Magnum
  - We’re testing it
- Kubernetes has built-in support, leverage on it

```
magnum baymodel-create --name rocha-bay-model --coe kubernetes --volume-driver cinder ...
```

- Swarm uses the REX-Ray docker volume plugin, which supports Cinder

```
magnum baymodel-create --name rocha-bay-model --coe swarm --volume-driver rexray ...
```

Upstream Contributions

- Everything we can is pushed upstream (as we do for all OpenStack projects)
- Puppet module contributions (puppet-magnum)
- Installation guide for Magnum
- Docker storage driver selection
  - x5 performance improvement using overlayfs instead of devicemapper (Fedora default)
- OpenStack Rally integration (monitoring of service in production)
- Availability Zones (AZ) awareness
- And other smaller patches..

- CERN OpenLab / Rackspace fellow (Spyros Trigazis)
- Also work in the context of the Indigo DataCloud project

Demos

- Deployment of a Kubernetes cluster
- Everware / Jupyter notebooks
- Scaling distributed processing

Summary & Plans

- Pilot service deployed, used by ~10 projects
  - Covering common use cases in our environment
  - Using production resources, but enabled only for a subset of projects
- Kubernetes, Docker Swarm/Compose fully supported
- With CVMFS and persistent storage support, first set of requirements fulfilled

- And coming next...
- Investigate access to EOS (credential handling is tricky)
- Integration with LBaaS (load balancing)
- Container Monitoring (cAdvisor, Heapster)
- Bay auto scaling (unclear on policies to use)

When can i use it?

- If you have a nice use case, you can use the pilot service today
  - Drop us an email to get access
- No big changes foreseen, service is quite stable
- Couple of bug fixes left to deal with

- Aiming for production Q3 2016

Questions ?

http://clouddocs.web.cern.ch/clouddocs/containers/index.html