Containers and HTCondor

Center for High Throughput Computing

Outline

- Why put contain jobs?

- Ersatz HTCondor containment
- Docker containers
- Singularity containers
- The Amazing Future Will Surprise You!

3 Protections

1) Protect the machine from the job.

2) Protect the job from the machine.

3) Protect one job from another job.

The ideal container

- Allows nesting
- Need not require root
- Can’t be broken out of
- Allows full management:
  - Creation // Destruction
  - Monitoring
  - Limiting

Resources a job can (ab)use

- CPU
- Memory
- Disk
- Network
- Signals
- L1-2-3 cache

MOUNT_UNDER_SCRATCH

- Or, “Shared subtrees”
- Goal: protect /tmp from shared jobs
- Requires
  - HTCondor must be running as root
  - MOUNT_UNDER_SCRATCH = /tmp,/var/tmp
- On by default as of HTCondor 8.8

MOUNT_UNDER_SCRATCH

```
MOUNT_UNDER_SCRATCH=/tmp,/var/tmp
```

Each job sees private /tmp, /var/tmp

Downsides:

No sharing of files in /tmp

Control Groups aka “cgroups”

- Two basic kernel abstractions:

  1) nested groups of processes

  2) “controllers” which limit resources

Control Cgroup setup

- A filesystemMounted on /sys/fs/cgroup,
  - Groups are *per controller*
    - E.g. /sys/fs/cgroup/memory/my_group
    - /sys/fs/cgroup/cpu/my_group
  - Condor default is
    - /sys/fs/cgroup/<controller>/htcondor
  - Compare with systemd's slices

Cgroup controllers

- Cpu
  - Allows fractional cpu limits
- Memory
  - Need to limit swap also or else…
- Freezer
  - Suspend / Kill groups of processes
- … any many others

Enabling cgroups

- Requires:
  - Rootly condor
  - On by default in HTCondor 8.8!
  - And… condor_master takes care of the rest

Cgroups with HTCondor

- Starter puts each job into own cgroup
  - Named exec_dir + job id
- Procd monitors
  - Procd freezes and kills atomically
- CPUS attr * 100 > cpu.shares
- MEMORY attr into memory controller
- CGROUP_MEMORY_LIMIT_POLICY
  - Hard or soft
  - Job goes on hold with specific message

Cgroups seem fiddly, why not let something else do it?

Enter Docker

Docker manages Linux containers via cgroups.
And gives Linux processes a private:

- Root file system
- Process space
- NATed network
- UID space

HTCondor docker universe

Need docker (maybe from EPEL)

```
$ yum install docker-io
```

Condor needs to be in the docker group!

```
$ useradd -G docker condor
```

Docker be running:

```
$ service docker start
```

What? No Knobs?

- condor_starter detects docker by default

```
$ condor_status -l | grep -i docker
HasDocker = true
DockerVersion = "Docker version 1.5.0, build a8a31ef/1.5.0"
```

- If docker is in a non-standard place
  DOCKER = /usr/bin/docker

We had to have some knobs

- DOCKER_DROP_ALL_CAPABILITIES
  - Evaluated with job and machine, *true* by default
  - If false, removes –drop-all-cap from docker run
- DOCKER_VOLUMES = CVMFS, SCR
- DOCKER_VOLUME_DIR_CVMFS = /cvmfs
- DOCKER_MOUNT_VOLUMES = CVMFS

Docker run has 1M options?

- DOCKER_EXTRA_ARGUMENTS

- Appends additional arguments to
  - docker create

“Docker” Universe jobs

```
universe = docker
docker_image = deb7_and_HEP_stack
executable = /bin/my_executable
arguments = arg1
transfer_input_files = some_input
output = out
error = err
log = log
queue
```

A docker Universe Job Is a Vanilla job

- Docker containers have the job-nature
  - condor_submit
  - condor_rm
  - condor_hold
  - Write entries to the ~~user log~~ event log
  - condor_dagman works with them
  - Policy expressions work.
  - Matchmaking works
  - User prio / job prio / group quotas all work
  - Stdin, stdout, stderr work
  - Etc. etc. etc.*

Docker Universe

```
universe = docker
docker_image =deb7_and_HEP_stack
# executable = /bin/my_executable
```

- Image is the name of the docker image on the execute machine. Docker will pull it
- Executable is from submit machine or image NEVER FROM execute machine!
- Executable is optional

(Images can name a default command)

Docker Universe and File transfer

```
universe = docker
transfer_input_files = <files>
When_to_transfer_output = ON_EXIT
```

- HTCondor volume mounts the scratch dir
  And sets the cwd of job to scratch dir
- RequestDisk applies to scratch dir, not container
- Changes to container are NOT transferred back
- Container destroyed after job exits

Docker Resource limiting

```
RequestCpus = 4
RequestMemory = 1024M
RequestDisk = Somewhat ignored…
```

- RequestCpus translated into cgroup shares
- RequestMemory enforced
  - If exceeded, OOM killed & job held
- RequestDisk applies to the scratch dir only
- 10 Gb limit rest of container

Enter Singularity

- Singularity like light Docker:
  - No daemon
  - Setuid wrapper binary
  - Can work without hub
  - Can work without setuid (but not by default)

Enabling Singularity for all jobs

- SINGULARITY = /usr/bin/singularity
- SINGULARITY_JOB = true
- SINGULARITY_IMAGE_EXPR =
  “/full/path/to/image”

…for some jobs

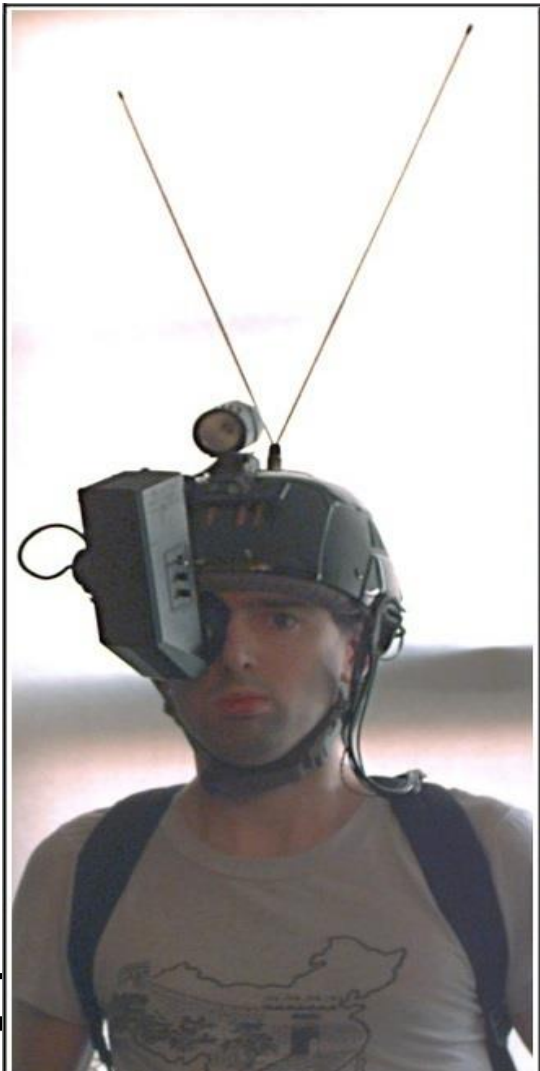
```
SINGULARITY_JOB = \
!isUndefined(TARGET.SingularityImage)


SINGULARITY_IMAGE_EXPR = \
    TARGET.SingularityImage
```

Singularity vs Docker

- Designed not as user focused, rather admin
- Jobs may not know when in singularity
- Startd focused

The Amazing Future…



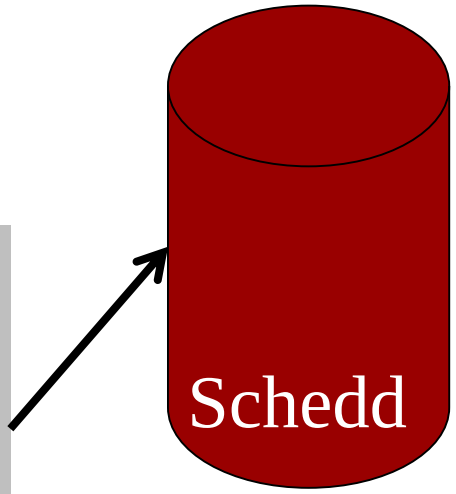
kubernetes

- Kubernetes
- allows interesting possibilities
- Runs containers
- Runs as root
- Provisions its own network
- Co-exist batch world with service world

First potential integration

- Kubernetes as grid type:

```
Universe = grid
Grid_type = k8s
hostname
k8s_image = my_image
…
queue
```

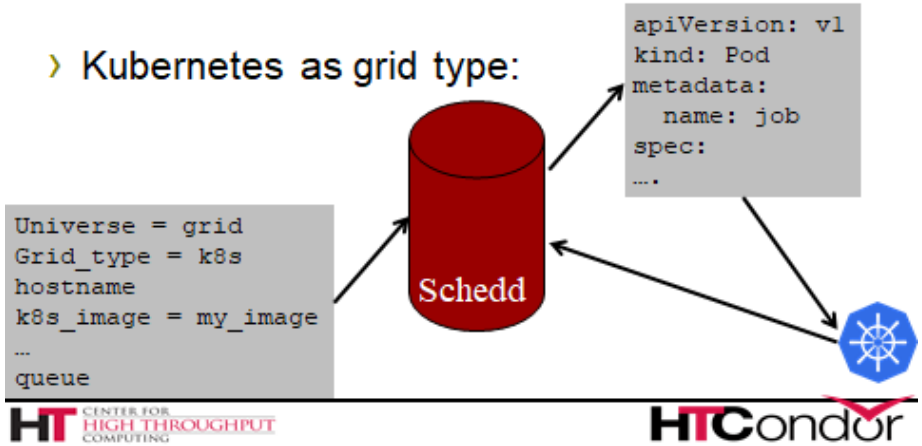



```
apiVersion: v1
kind: Pod
metadata:
  name: job
spec:
….
```

- One scheduler
- K8s sees jobs

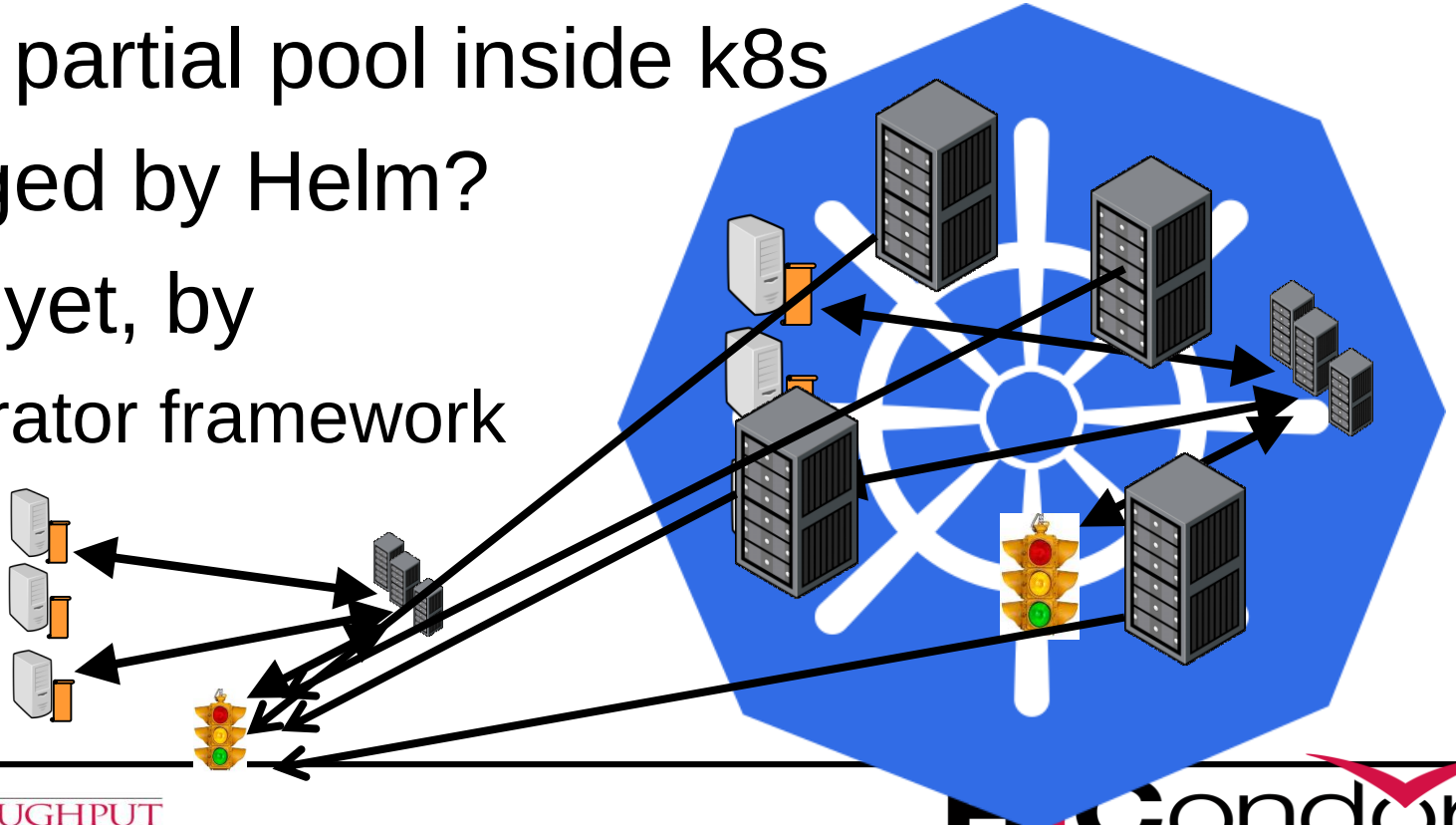
First potential integration

- Kubernetes as grid type:



Second potential integration

- Full or partial pool inside k8s
- Managed by Helm?
- Better yet, by
  - Operator framework



Questions?

Thank you!