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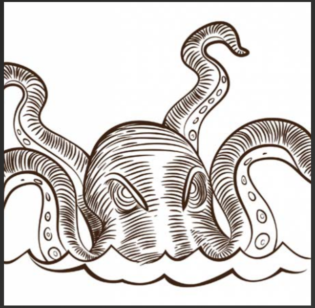

slurm
workload manager

docker

Charliecloud

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LA-UR-18-29031

Slurm in a container only world

Are we crazy?

Paul Peltz and Lowell Wofford

9/25/2018

Why Containers?

- **Users are demanding it for Crossroads**
  - Reproducibility
  - Supportability
  - Consistency
- **System Support staff as well?**
  - Support burden shifts to the user

Containers Pros/Cons

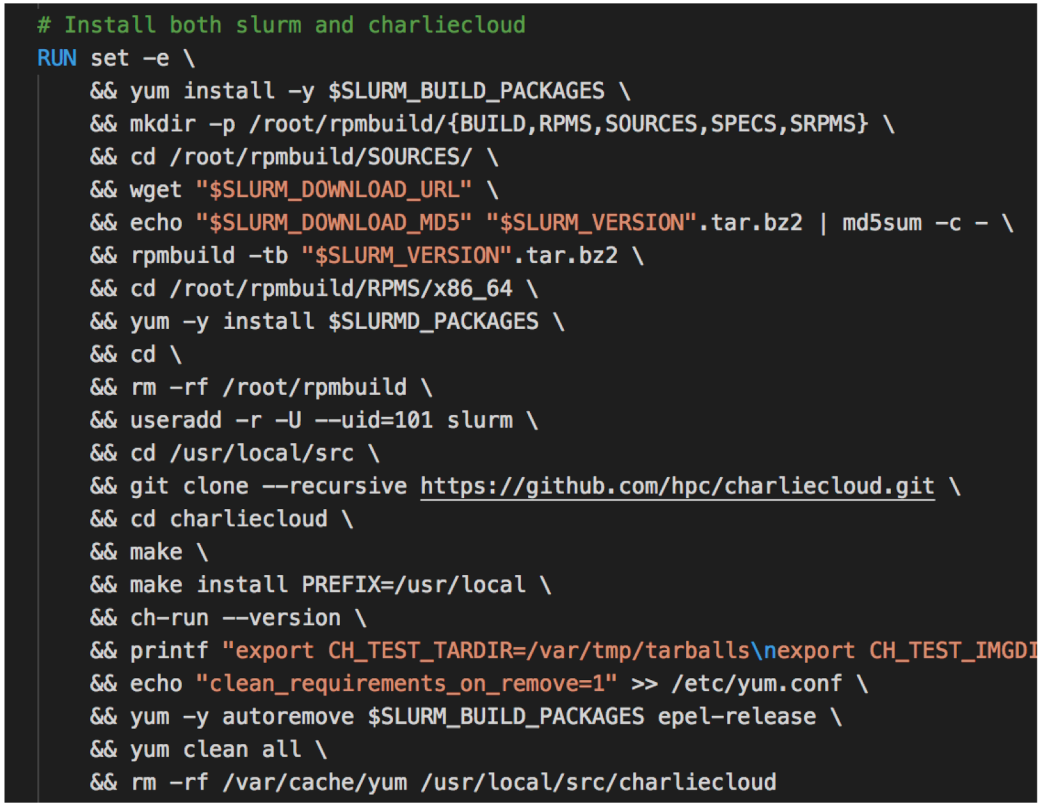
- **Pros**
  - Boot once, Run forever*
  - Rolling Upgrades!
- **Cons**
  - Multi-Service containers
  - Containers within containers can be tricky
- **Unknowns**
  - Containers as base OS never been attempted?
  - Memory usage?
  - Security Implications?

Multi-Service Containers

- **Interesting Use Case**
  - Systemd or not?
    - Systemd requires additional privileges to run
    - Probably can't do it with u-root's unshare
  - Supervisord
    - Service manager for containers
    - Many of the same controls for managing services
    - Unit-like file definitions
  - Slurmd

```
[program:slurmd]
command=/usr/sbin/slurmd -Dvvv
user=root
autostart=true
```

Dockerfile for layer1



```
# Install both slurm and charliecloud
RUN set -e \
    && yum install -y $SLURM_BUILD_PACKAGES \
    && mkdir -p /root/rpmbuild/{BUILD,RPMS,SOURCES,SPECS,SRPMS} \
    && cd /root/rpmbuild/SOURCES/ \
    && wget "$SLURM_DOWNLOAD_URL" \
    && echo "$SLURM_DOWNLOAD_MD5" "$SLURM_VERSION".tar.bz2 | md5sum -c - \
    && rpmbuild -tb "$SLURM_VERSION".tar.bz2 \
    && cd /root/rpmbuild/RPMS/x86_64 \
    && yum -y install $SLURMD_PACKAGES \
    && cd \
    && rm -rf /root/rpmbuild \
    && useradd -r -U --uid=101 slurm \
    && cd /usr/local/src \
    && git clone --recursive https://github.com/hpc/charliecloud.git \
    && cd charliecloud \
    && make \
    && make install PREFIX=/usr/local \
    && ch-run --version \
    && printf "export CH_TEST_TARDIR=/var/tmp/tarballs\nexport CH_TEST_IMGDI
    && echo "clean_requirements_on_remove=1" >> /etc/yum.conf \
    && yum -y autoremove $SLURM_BUILD_PACKAGES epel-release \
    && yum clean all \
    && rm -rf /var/cache/yum /usr/local/src/charliecloud
```

- CentOS 7 based
- Download and install slurm and charliecloud
- Start supervisord
  - slurmd
  - rsyslogd
  - sshd
  - munge
- Copy in things like ssh keys and munge keys
- Currently about 362MB

docker run -dt -p 6818:6818 -p 3222:22 -h c1 --mount type=bind,source="/home/peltz",target=/home/peltz --security-opt='seccomp=unconfined' --name layer1 kraken/layer1-supervisord:1.0

Slurm for deployment of Containers

- **How about sbcast?**
  - Doesn’t perform at scale to distribute container image
  - May also depend on what network your slurm communication happens over, e.g. 1Gb Ethernet vs HSN
- **Private Registry?**
  - N-1 problem
- **See next slide for testing results**
  - https://bit.ly/2xxoGYa

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Evaluating Container Image Distribution Methods for HPC Using Charliecloud

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Mentors: Reid Priedhorsky, Tim Randles

Overview

Containers have many benefits such as portability and freedom from a provided software stack. We studied several container image distribution methods for use with Charliecloud at scale.

Methods

- Experiment factors: distribution method, application, cluster, and node count
- Five repetitions for each job configuration
- Charliecloud as primary tool for building, compressing, and uncompressing images
- Modular scripting scheme to automate job submission and monitoring

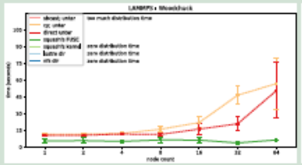
Woodchuck Specifications

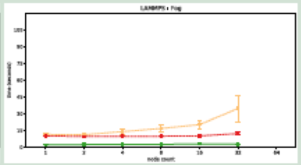
- 192 compute nodes
- 10Gbps Ethernet
- 16 cores, 2.4GHz, per node

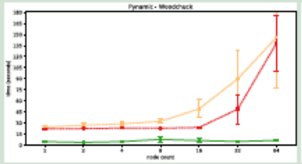
Fog Specifications

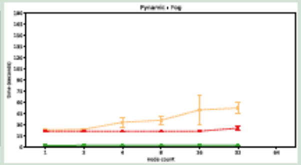
- 32 compute nodes
- 100Gbps Intel Omni-Path
- 36 cores, 2.1GHz, per node

Direct Untar, SquashFS Winners





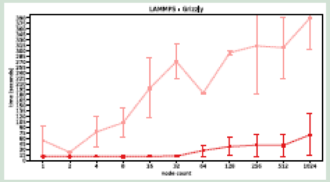




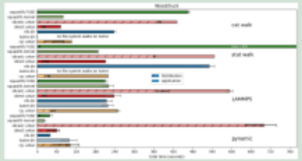
Poor Sbcast Performance at Scale

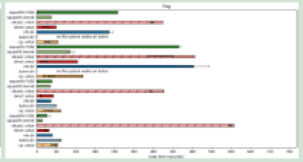
Grizzly Specifications:

- 1490 compute nodes
- 100Gbps Intel Omni-Path
- 36 cores, at 2.1GHz per node



Application Times





Conclusions

Question	Answer
Fastest network method?	Kernel-Mounted SquashFS
Fastest in-memory method?	Direct Untar
Network method impact on time?	Varies with application by I/O

Other Questions

Question	Answer
What is the runtime overhead of a FUSE-mounted SquashFS?	Minimal, unless I/O intensive application
Is Sbcast effective at a larger scale?	No. (but see limitations)

Limitations

- Cat walk and stat walk could not be run on Lustre due to concerns of overloading the metadata server
- Pynamic's benchmark time is produced by Pynamic itself instead of the 'time' command
- We tested only the Direct Untar and Sbcast methods at a large scale (128-1024 nodes)
- Distribution times can be affected by network congestion on Lustre and NFS
- LAMMPS does not scale as we expect for reasons we do not understand
- Sbcast may be running over the management network
- LAMMPS was unable to run at 128 nodes on Woodchuck

Future Work

Perform tests…

- with other scientific applications e.g. Vector Particle-In-Cell (VPIC)
- with larger node counts (512, 1024, 2048) across all applications
- on a Cray System
- with different file size profiles
- while monitoring various confounding factors e.g. Lustre, unpack speed, network
- on SquashFS methods in NFS
- that analyze other resource use (RAM, network bandwidth, etc.)

Generic slurm plugin for containers

- **Not necessary for some methods of container usage**
  - squashFS from PFS
- **Slurm running charliecloud**
  - Not difficult and no special plugins required

```
[peltz@c1 ~]$ cat slurm-1230.out
tarball: /home/peltz/mpihello.tar.gz
image: /var/tmp/mpihello replacing existing image /var/tmp/mpihello
/var/tmp/mpihello unpacked ok
container: mpirun (Open MPI) 2.1.5 0:
init ok c1, 1 ranks, userns 4026533176 0:
send/receive ok 0:
finalize ok
```

Future Work

- **What if slurmd was not the source of node state information?**
  - Slurmctld queries an API for Kraken or other system state managers
    - For example, Cray's system software wants to be the source of truth for system state
    - Historically the cray system and slurmctld do not agree
      - Must wait for timeouts
      - Or utilities such as slurmsmwd
- **Cut out docker as the container runtime for layer1**
  - Use unshare directly from u-root
- **Go get kraken**
  - https://github.com/hpc/kraken/

Thanks!