Introduction to Running Hadoop on the High Performance Clusters at the Center for Computational Research

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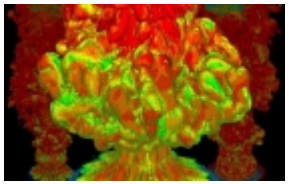
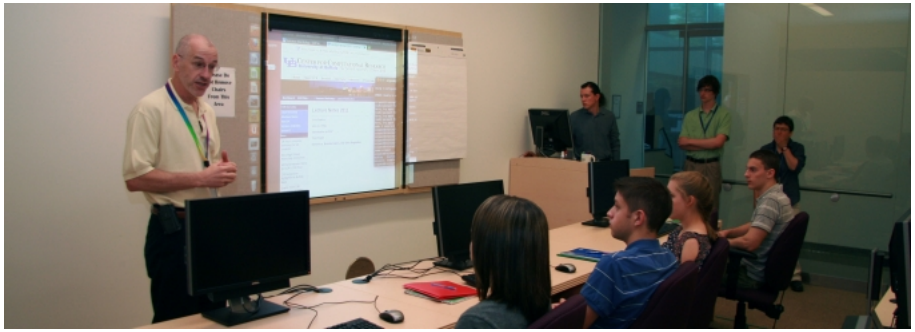
CCR

The Center for Computational Research is the supercomputing facility for the University at Buffalo.

CCR's mission is three-fold:

- Research
- Education
- Outreach





Cluster Resources

- 256 computers 8-cores with 24GB memory
- 372 computers 12-cores with 48GB memory
- 16 computers 32-cores with 256GB memory
- 2 computers 32-cores with 512GB memory

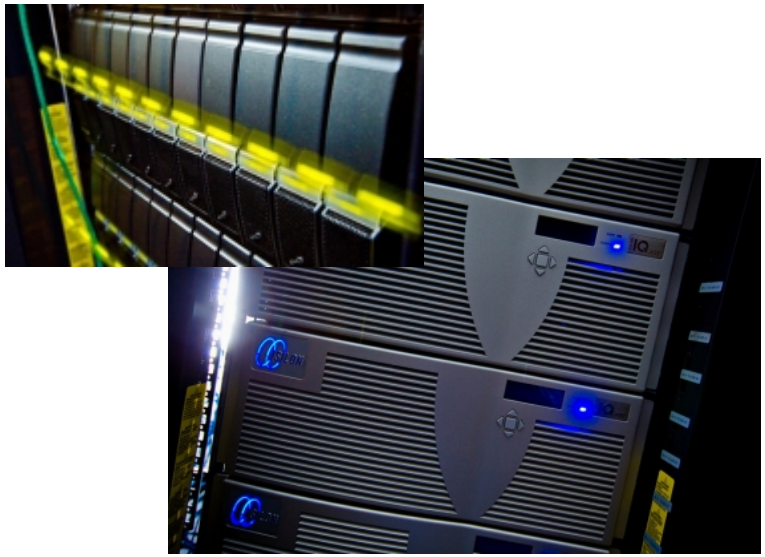
- 32 computers 12 cores with 48GB memory and 2 GPUs

COMING SOON

- 32 16-core machines
- Remote Visualization System

Cluster Resources

- 505TB of networked attached storage
- Backup of home and projects directories



more on cluster resources

- High performance Infiniband fabric network

- Command line interface
- Batch scheduling access to cluster machines

Data Storage

Permanent Data Storage

- Home directory
  - 2GB
  - /user/username
  - Back up
- Projects directory
  - 200GB – 500GB
  - /projects/groupname
  - Group space
  - Requested by Academic Research Advisor
  - Back up

Temporary Data Storage

- Panasas directory
  - /panasas/scratch
  - 215TB
  - Files older than 2 weeks are automatically deleted
  - Available on all nodes
- Scratch directory
  - /scratch
  - 256GB – 3TB
  - Local to compute node
  - Files deleted at end of job

Accessing the Cluster

Login Machine

- The CCR cluster front-end machine is **u2.ccr.buffalo.edu**
- 32-core node with 256GB of memory
- Login to cluster
- Transfer data files to and from cluster data storage
- Command line Linux environment
- Compile code, edit files and submit jobs to cluster

- Compute nodes and storage spaces are not directly accessible from outside the cluster.
- Small computations on login machine
- Accessible from UB network only
  - LAN or UB Secure Wireless on campus
  - Use UB VPN from off campus to connect to UB network

Accessing the Cluster

From Windows Machines

- Login
  - XWin-32 program
  - Allow graphical display back to user's workstation/laptop
  - PuTTY secure shell program
- File transfer
  - Filezilla or WinSCP are graphical file transfer programs
  - scp/sftp available in the PuTTY package
- UB VPN for off-campus access

More on:

- Xwin-32
- Filezilla
- WinSCP
- UB VPN
- User Guide

Accessing the Cluster

From Linux and MAC Machines

- Login
- ***ssh username@u2.ccr.buffalo.edu***
- ***ssh -X username@u2.ccr.buffalo.edu***
  - Allow graphical display back to user's workstation/laptop
- File transfer
  - Filezilla is a graphical file transfer program
  - sftp or scp
- UB VPN for off-campus access

More on:

- ssh/sftp/scp
- UB VPN for Linux
- UB VPN for MAC
- User Guide

Command Line

- List the contents of a directory: ***ls -l***
- Displays ownership and permissions.
- Show details and hidden files: ***ls -la***
- Show details in reverse time order: ***ls -latr***
- Show current directory pathname: ***pwd***
- Create a directory: ***mkdir dirname***

- Change directory: ***cd /pathname***
- Change to one directory above: ***cd ..***
- Change to two directories above: ***cd ../..***
- Change to home directory: ***cd***
- Remove a file: ***rm filename***
- Remove a directory: ***rm -R dirname***

Command Line

- **All directories and files have permissions**.
- Users can set the permissions to allow or deny access to their files and directories.
- Permissions are set for the user (u), the group (g) and everyone else (o).
- The permissions are read, write and execute.
- drwxrwxrwx
- -rwxrwxrwx

- Read (r) permission allows viewing and copying.
- Write (w) permission allows changing and deleting.
- Execute (x) permission allows execution of a file and access to a directory.
- Show permissions: ***ls -l***
- The left most is – for a file and d for a directory.
- The next three are read, write and execute for the user (owner).

Command Line

- The middle three are read, write and execute for the group.
  - These permissions set the access for all members of the group.
- The rightmost three are read, write and execute for other.
- Change permissions with the chmod command.
- ***chmod ugo+rwx filename***
- ***chmod ugo-rwx filename***

- ugo is user, group and other
- rwx is read, write and execute
  - + add a permission
  - - removes a permission
- Adding write permission for group:
  - ***chmod g+w filename***
- Removing all permissions for group and other on a directory and its contents:
  - ***chmod -R go-rwx dirname***

Command Line

- The asterisk is a wild card for many UNIX commands.
  - List all C files: ***ls *.c***
- Files edited on Windows machines can contain hidden characters, which may cause runtime problems.
- Use the file command to show the type of file.
  - If the file is a DOS file, then use the dos2unix command to remove any hidden characters.

- Viewing files: cat, more or less
- ***cat filename*** displays a file to the screen
- ***more filename*** displays a file to the screen with page breaks
- ***less filename*** allows paging forward and back
- There are several editors available.
  - emacs, gedit, nano and vi

Command Line

- Files edited on Windows machines can contain hidden characters, which may cause runtime problems.
- Use the file command to show the type of file.
  - If the file is a DOS file, then use the dos2unix command to remove any hidden characters.
  - ***file filename***
  - ***dos2unix filename***

- Manual pages are available for UNIX commands.
  - ***man ls***
- Change password using the MyCCR web interface
  - More on MyCCR
- See the CCR user guide for more information.

more on the User Guide

CCR Command Line Reference Card

Modules

- Most applications installed on the cluster have a module file that sets paths and variables.
- Loading a module adds the path for the application to path variables and sets variables.
- Unloading a module removes the path and unsets the variables.

- List available modules
  - ***module avail***
  - ***module avail intel***
- Show what a module will do
  - ***module show module-name***
- Load a module
  - ***module load module-name***
- Unload a module
  - ***module unload module-name***

Modules

- List modules currently loaded
  - ***module list***
- Users can create custom modules to point to their own software installations.
- Creating your own module.
  - Create the privatemodules directory in your home directory.
  - Copy a module to the privatemodules directory.
  - Edit the module.
- Using your own module.
  - Load the use.own module.
    - ***module load use.own***
  - Load the module.
    - ***module load your-module-name***

Running on the Cluster

- Computations are submitted to the PBS (Portable Batch System) scheduler as jobs to run on the cluster.
  - Jobs can be script or interactive.
- The compute nodes are assigned to jobs by the scheduler.
- Users are not permitted to use compute nodes outside of the scheduled job.

- The qsub command is used to submit a job to the cluster.
- Specify the number and type of nodes.
  - -lnodes=2:IB2:ppn=8
    - Requests 2 compute nodes and 8 processors per node.
    - Total of 16 processors.
    - The IB2 tag specifies the 8-core nodes.

Running on the Cluster

- -lnodes=4:IB1:ppn=12
  - Requests 4 compute nodes and 12 processors per node.
  - Total of 48 cores.
  - The IB1 tag specifies the 12-core nodes.
- The PBS tags IB1 and IB2 stand for InfiniBand fabrics (networks) 1 and 2, corresponding to 12-core and 8-core nodes.

- Specify the length of time.
  - This is the walltime of the job. The maximum allowed walltime is 72 hours.
- Most jobs will run in the default queue.
  - There is no need to specify this queue.
- Using the `-I` flag on the command line requests an interactive job.

more on cluster nodes and PBS tags

Running on the Cluster

- The cluster has a debug queue for quick testing of codes.
  - The maximum walltime is 1 hour.
  - There are 2 8-core nodes, 2 12-core nodes, and 1 GPU node.
- Use the “-q debug” flag to request the debug queue.

- Submit the job.
  - ***qsub pbs-script***
- Show job status with the qstat command.
  - ***qstat -an -u username***
  - ***qstat jobid***
- A job will have a queued or run state.
  - Jobs in a run state have a node list.
  - The cores are indicated in the node list.

Running on the Cluster

- The first node in the head node of the job.
- The qdel command will delete a job.
  - ***qdel jobid***
- The showstart command will give an estimated start time for a job.
  - ***showstart jobid***
  - The start time is estimated based on the current queue. This value can change.

- The showq command with display the queue status. The running jobs are shown first, followed by the queued or idle jobs.
  - ***showq***
- pipe is helpful with showq: ***showq | more***
- The showbf command will show nodes that currently available.
  - ***showbf -S***
  - ***showbf -S | more***

Hadoop on the Cluster

- There are two methods of running a Hadoop computation on the cluster.
- The first is to use the MyHadoop scripts to set up and run the Hadoop computation.
- The second is an interactive job. We will look at this option later.
- Using the MyHadoop scripts:

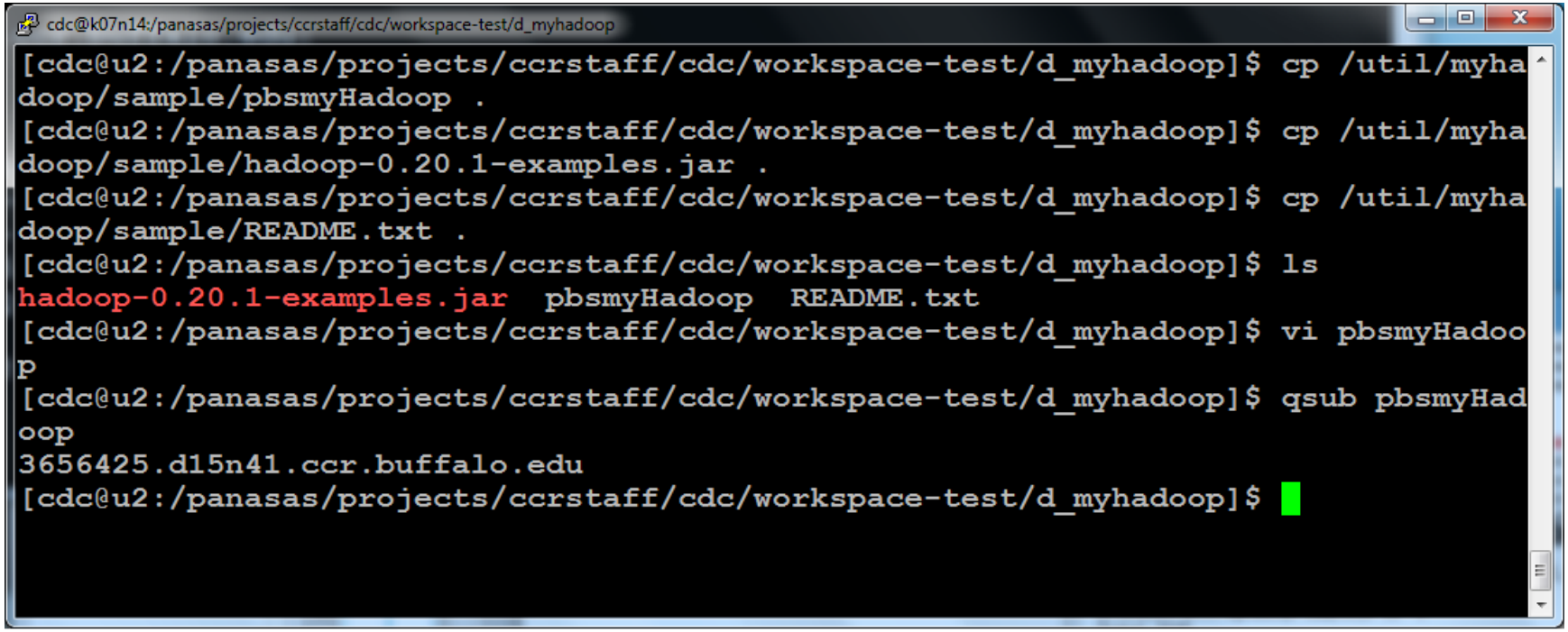
- Change to working directory.
- Copy the pbsmyHadoop, hadoop-0.20.1-examples.jar and README.txt files from the /util/myhadoop/sample directory.
- ***cp /util/myhadoop/sample/pbsmyHadoop .***
- ***cp /util/myhadoop/sample/hadoop-0.20.1-examples.jar .***

Hadoop on the Cluster

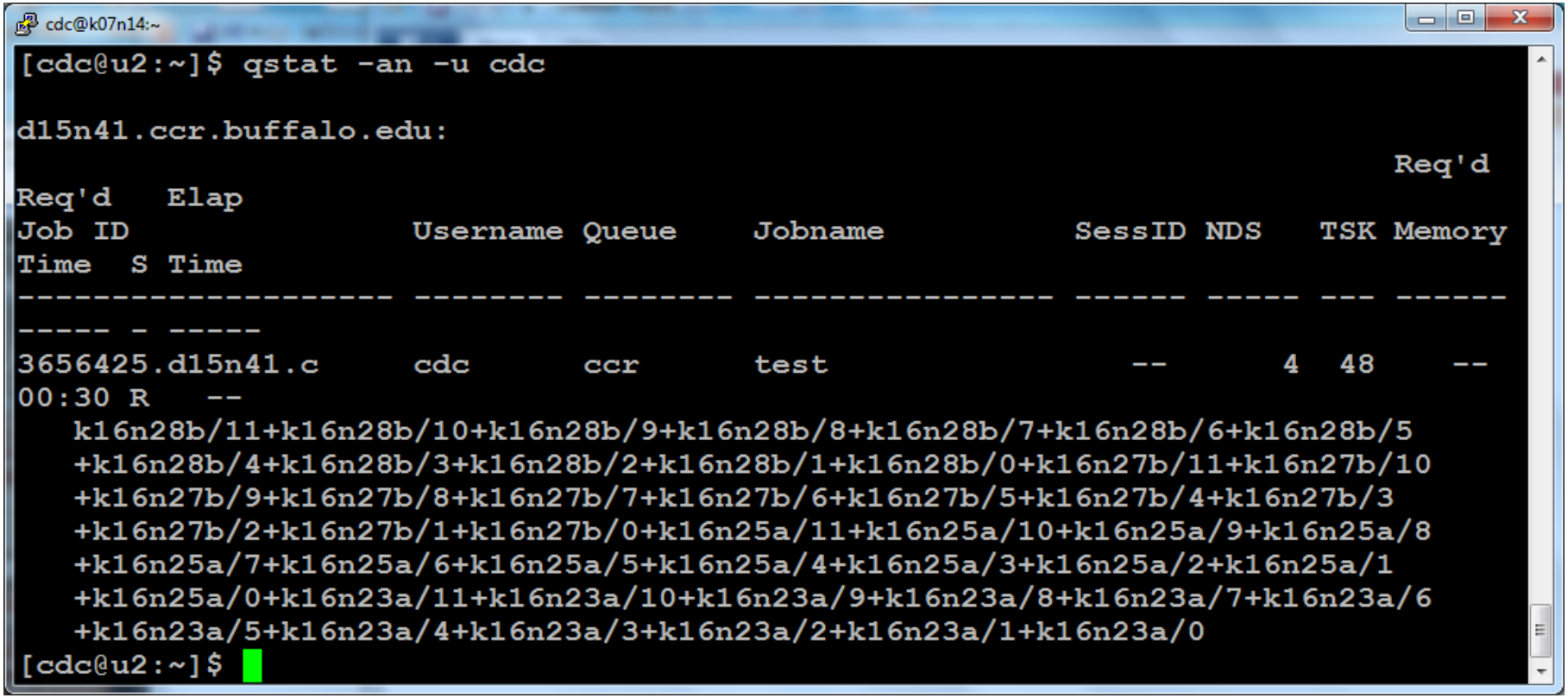
- ***cp /util/myhadoop/sample/README.txt .***
- Edit the pbsmyHadoop file.
- ***emacs pbsmyHadoop***
- Submit the job.
- ***qsub pbsmyHadoop***
- Show the job in the queue.
- ***qstat -an -u username***
- ***qstat -an jobid***

- The config directory is created in the working directory.
- The output file will be in this directory when the job completes.
- Monitor the job the ccrjobviz.pl command.
- ***ccrjobviz.pl jobid***

Submitting a Job



Running a Job



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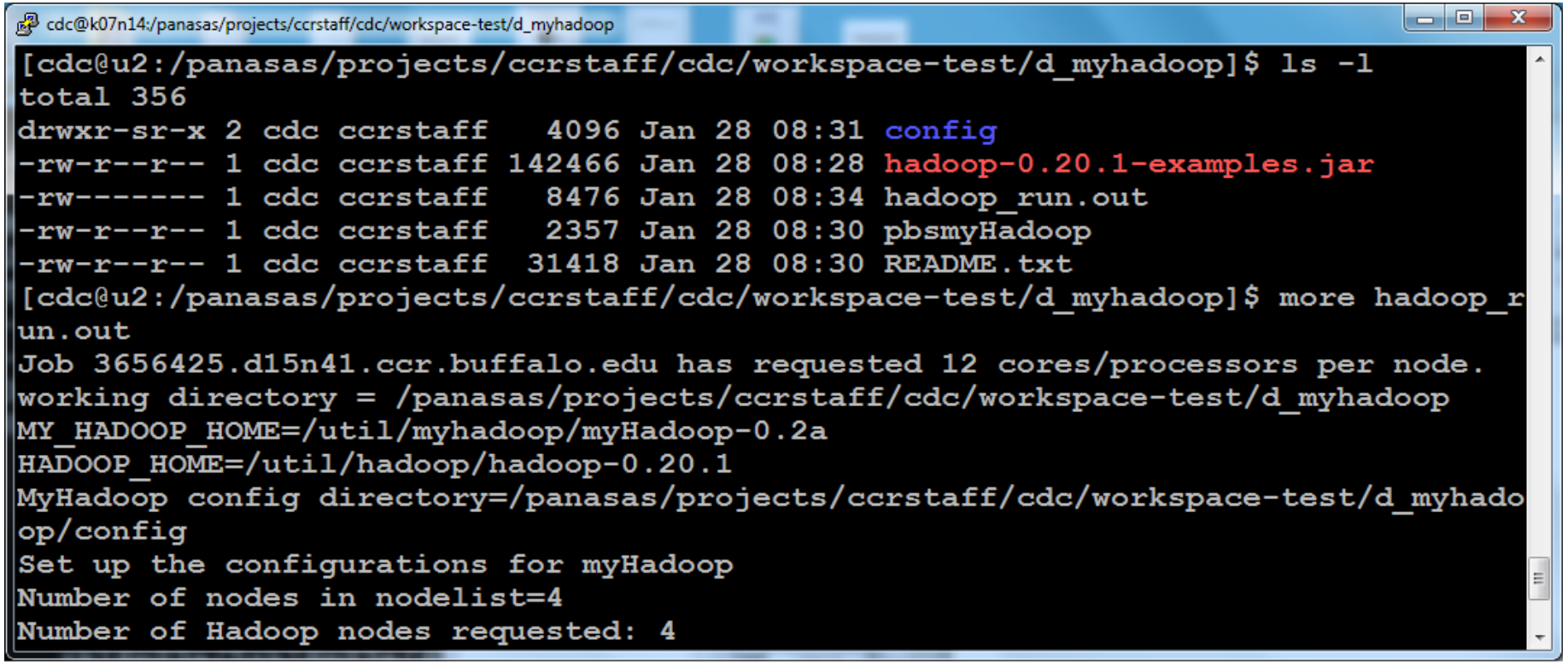

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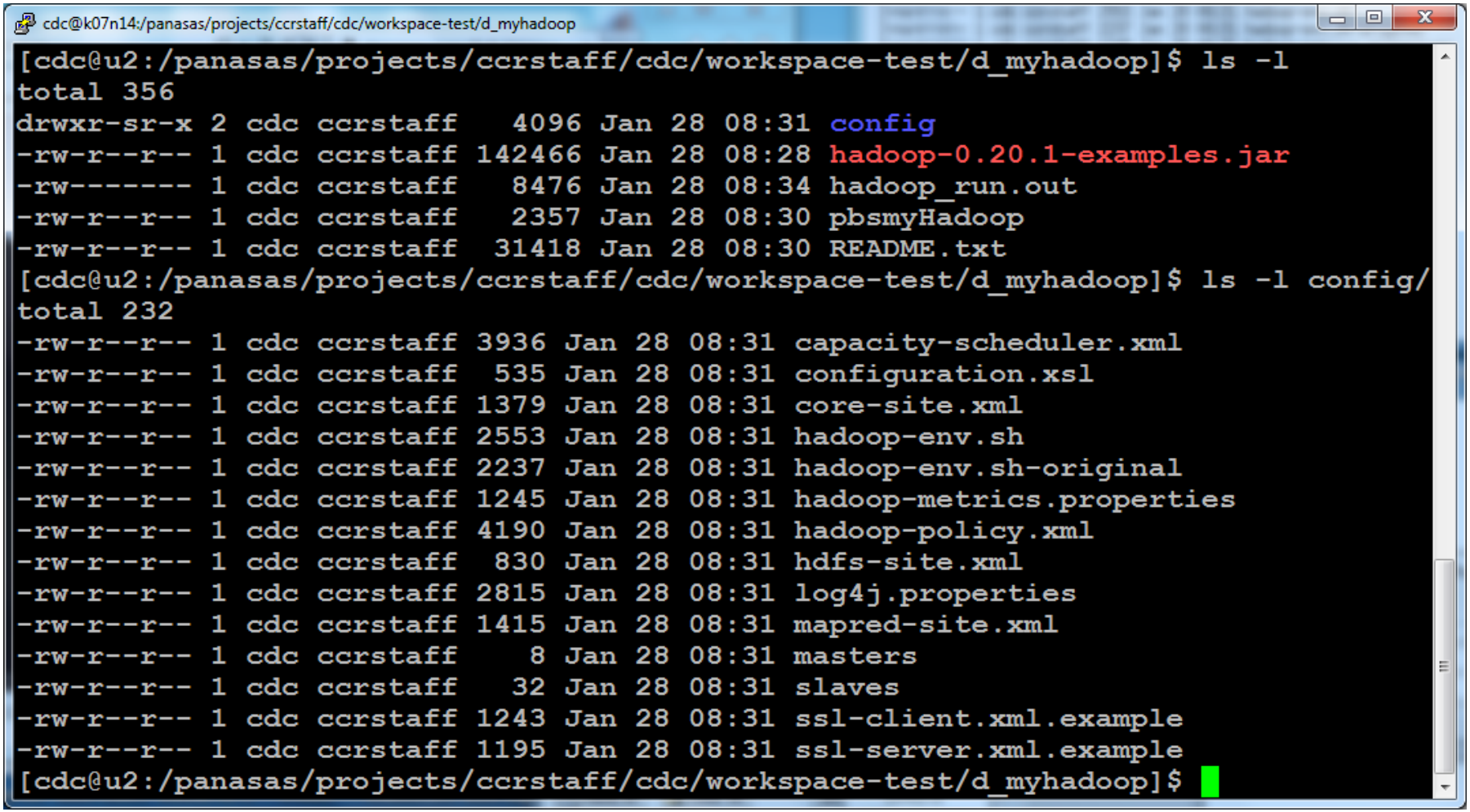


pbsmyHadoop Script page 1

```
#!/bin/bash
#PBS -l nodes=4:IB1:ppn=12
#PBS -l walltime=00:30:00
#PBS -M cdc@buffalo.edu
#PBS -m e
#PBS -N test
#PBS -o hadoop_run.out
#PBS -j oe

cd $PBS_O_WORKDIR
...
```

- specify bash shell
- node request
- time request
- email address
- email on job exit
- name of job
- output file
- stdout and stderr go to same output file
- change to the directory from which the job was submitted.

pbsmyHadoop Script page 2

```
echo "working directory = "$PBS_O_WORKDIR
. $MODULESHOME/init/sh
module load myhadoop/0.2a/hadoop-0.20.1
echo "MY_HADOOP_HOME="$MY_HADOOP_HOME
echo "HADOOP_HOME="$HADOOP_HOME
#### Set this to the directory where Hadoop configs should be generated
# Don't change the name of this variable (HADOOP_CONF_DIR) as it is
# required by Hadoop - all config files will be picked up from here
#
# Make sure that this is accessible to all nodes
export HADOOP_CONF_DIR=$PBS_O_WORKDIR/config
echo "MyHadoop config directory="$HADOOP_CONF_DIR
```

pbsmyHadoop Script page 2

- Display the working directory.
- Initialization modules.
- Load the module file for myhadoop.
- Display the value of the $MY_HADOOP_HOME variable.
- Display the value of the $HADOOP_HOME variable.
- Set the $HADOOP_CONF_DIR to the config directory in the working directory.
- Display the value of the $HADOOP_CONF_DIR variable.

pbsmyHadoop Script page 3

```
### Set up the configuration
# Make sure number of nodes is the same as what you have requested from PBS
# usage: $MY_HADOOP_HOME/bin/pbs-configure.sh -h
echo "Set up the configurations for myHadoop"
# this is the non-persistent mode
NNuniq=`cat $PBS_NODEFILE| uniq | wc -l`
echo "Number of nodes in nodelist="$NNuniq
$MY_HADOOP_HOME/bin/pbs-configure.sh -n $NNuniq -c $HADOOP_CONF_DIR

sleep 15
```

pbsmyHadoop Script page 3

- Create a unique node list using the $PBS_NODEFILE variable.
  - The $PBS_NODEFILE variable contains a list of the compute nodes assigned to the job with each node listed as many times as cores on the node.
  - `cat $PBS_NODEFILE| uniq | wc -l ` means display the nodefile and filter it through the unique command, then count the number of lines that are output
- Run the configure script .
- Wait for 15 seconds.

pbsmyHadoop Script page 4

```
# this is the persistent mode
# $MY_HADOOP_HOME/bin/pbs-configure.sh -n 4 -c $HADOOP_CONF_DIR -p -d /oasis/clo
udstor-group/HDFS

#### Format HDFS, if this is the first time or not a persistent instance
echo "Format HDFS"
$HADOOP_HOME/bin/hadoop --config $HADOOP_CONF_DIR namenode -format

sleep 15

echo "start dfs"
$HADOOP_HOME/bin/start-dfs.sh

sleep 15
```

pbsmyHadoop Script page 4

- Format the HDFS on the compute node. The HDFS (Hadoop Distributed File System) is created using the local disk of each compute node running the job.
- Wait 15 seconds.
- Start the dfs.
- Wait 15 seconds.

pbsmyHadoop Script page 5

```
echo "copy file to dfs"
$HADOOP_HOME/bin/hadoop --config $HADOOP_CONF_DIR
dfs -put README.txt /

sleep 15

echo "ls files in dfs"
$HADOOP_HOME/bin/hadoop --config $HADOOP_CONF_DIR
dfs -ls /

echo "start jobtracker (mapred)"
$HADOOP_HOME/bin/start-mapred.sh

echo "ls files in dfs"
$HADOOP_HOME/bin/hadoop --config $HADOOP_CONF_DIR
fs -ls /
```

pbsmyHadoop Script page 5

- Copy file to dfs.
- Wait 15 seconds.
- List the files in dfs.
- Start the job tracker.
- List the files in dfs.

pbsmyHadoop Script page 6

```
echo "run computation"
$HADOOP_HOME/bin/hadoop --config $HADOOP_CONF_DIR jar
hadoop-0.20.1-examples.jar
 wordcount /README.txt /output

echo "ls files in dfs"
$HADOOP_HOME/bin/hadoop --config $HADOOP_CONF_DIR fs -ls
/output

echo "view output results"
$HADOOP_HOME/bin/hadoop --config $HADOOP_CONF_DIR fs -
cat /output/part-r-00000

echo "stop jobtracker (mapred)"
$HADOOP_HOME/bin/stop-mapred.sh

echo "stop dfs"
$HADOOP_HOME/bin/stop-dfs.sh
```

pbsmyHadoop Script page 6

- Run the computation.
- List the files in dfs.
- View the results.
- Stop the job tracker.
- Stop the dfs.

pbsmyHadoop Script page 7

```
#### Clean up the working directories after job completion
echo "Clean up"
$MY_HADOOP_HOME/bin/pbs-cleanup.sh -n $NNuniq
echo
```

pbsmyHadoop Script page 7

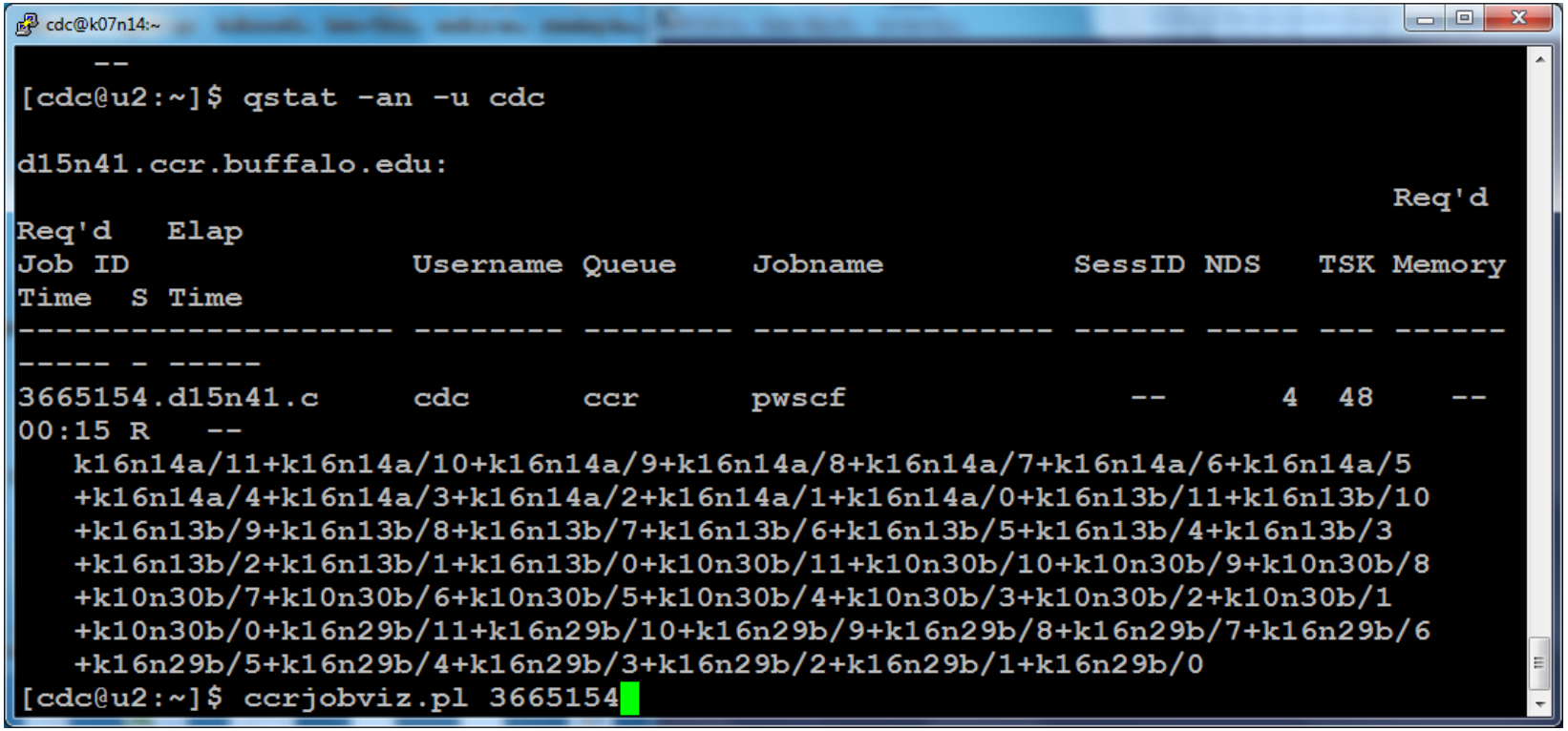
- Run the cleanup script.

Monitoring a Job

- ccrjobviz.pl is a graphical display used to monitor and evaluate a running job.
  - ***ccrjobviz.pl jobid***
- The top command can used to monitor the processes on a node.
  - Use **qstat -an -u username** or ***qstat -an jobid***
  - ssh into the node: ***ssh nodename***
  - Run top on the node: ***top***

- The first node in the list is the head node of the job, which contains the standard output and error file while the job running.
  - ssh into the node: ***ssh nodename***
  - ***cd /var/spool/pbs/spool***
  - The output file will have the jobid as the file name.
  - ***cat jobid***

Monitoring a Job



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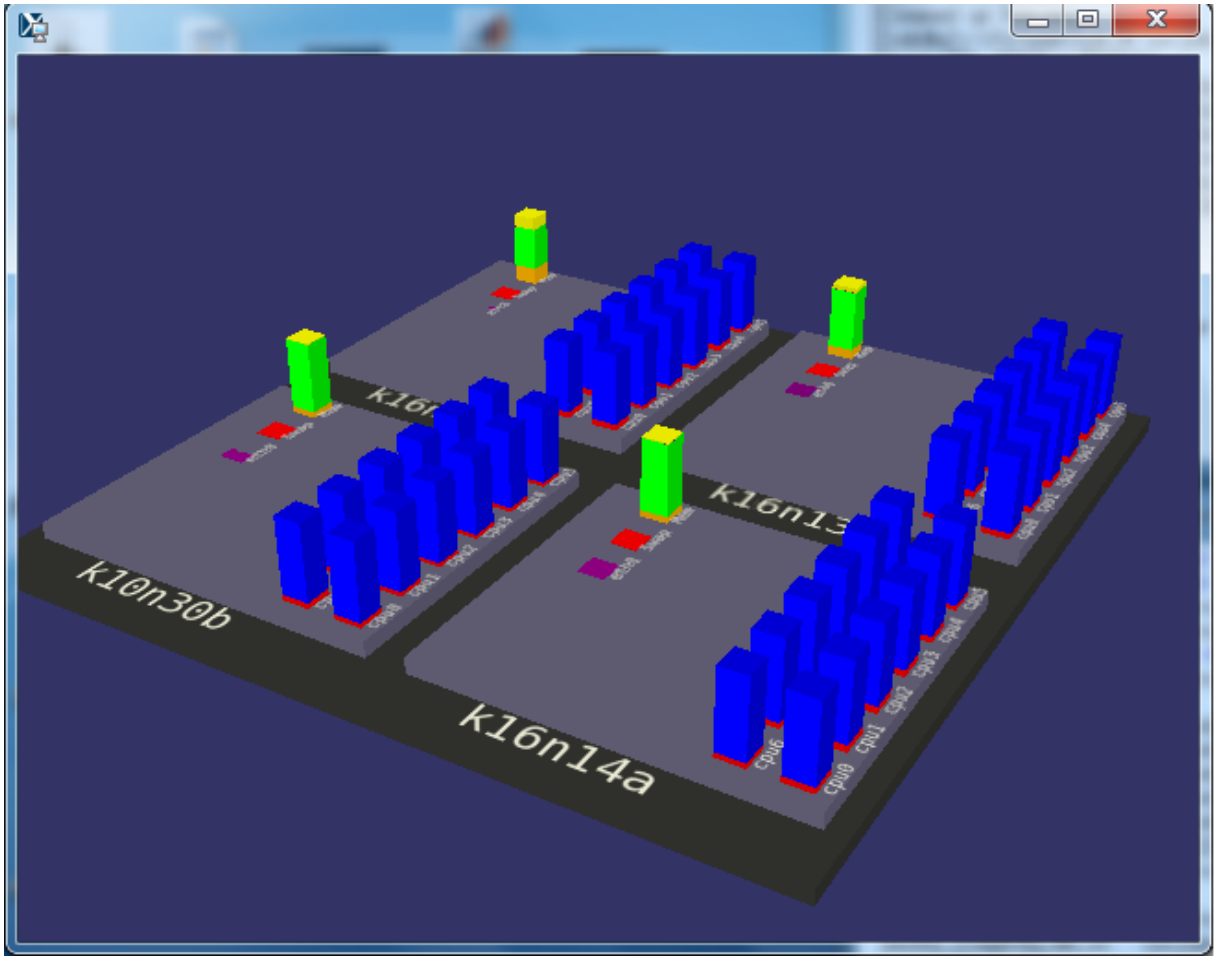


Hadoop on the Cluster

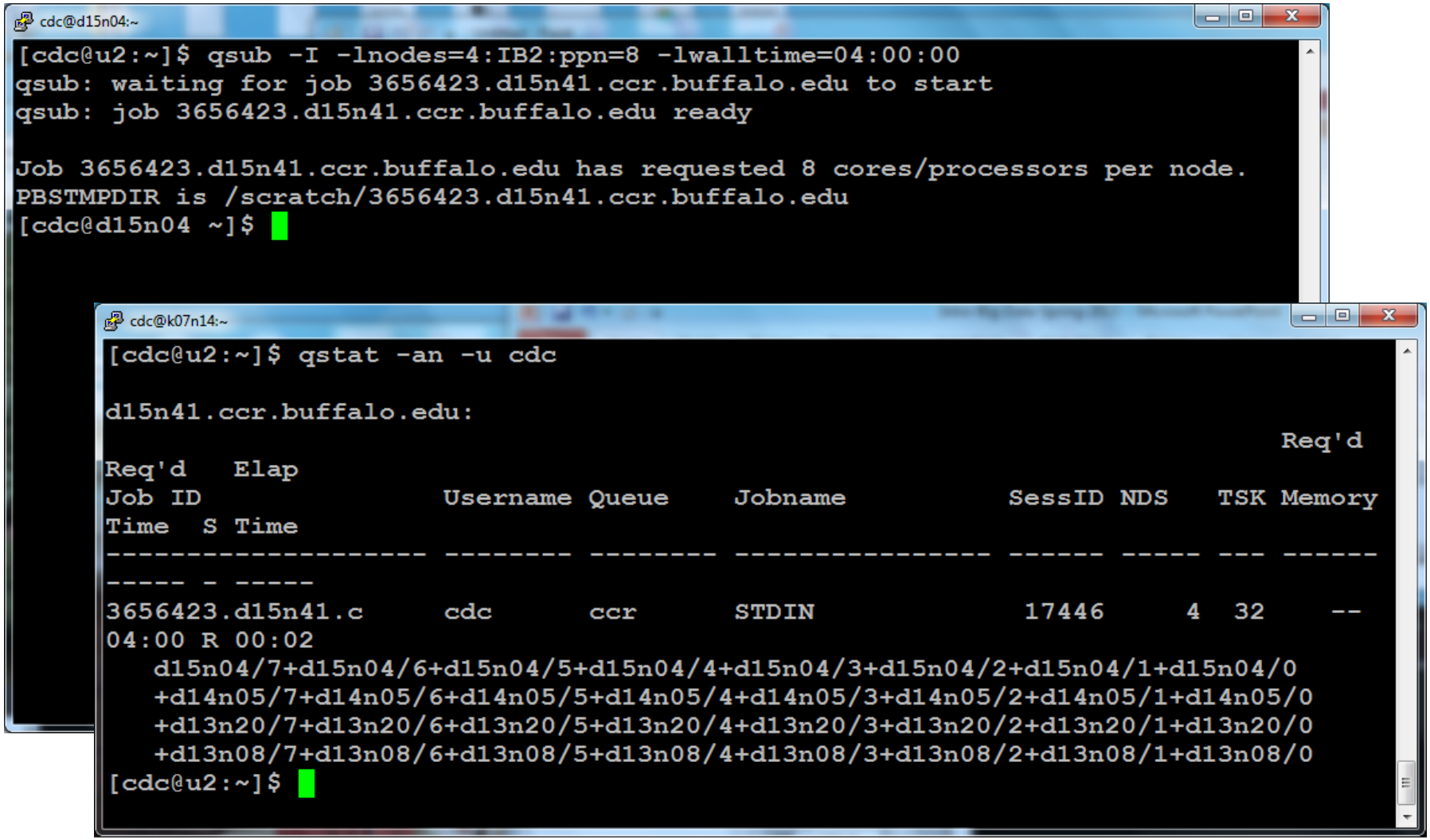
- The second method of running a Hadoop computation is to use an interactive job.
- Submit an interactive job.
- ***qsub -I***

  -lnodes=4:IB2:ppn=8

  -lwalltime=03:00:00
- Once the job starts, configure Hadoop by hand and run the computation.

- This will take more time, however you will learn the specific configuration steps necessary for the hadoop computation.
- Here are the instructions: Running Hadoop - CCR

Submitting an Interactive Job



User Support

Online Resources:

New User Information

User Guide

Tutorials and Presentations

Help:

CCR staff members are available to assist you.

UB Faculty and student can request individual and group training sessions.

more on CCR Help