

BLUE WATERS

SUSTAINED PETASCALE COMPUTING

May 11, 2017

Application-Level Regression Testing Framework using Jenkins

Timothy A. Bouvet, NCSA, University of Illinois
Reuben D. Budiardja, ORNL, Oak Ridge, Tennessee
Galen W. Arnold, NCSA, University of Illinois
Gregory H. Bauer, NCSA, University of Illinois



GREAT LAKES CONSORTIUM
FOR PETASCALE COMPUTATION



Talk Outline

- Introduction and Motivation
- Implementation & Deployment
 - Basic Configuration
 - Connecting to multiple HPC systems
 - Security consideration, authentication, authorization
- Application Test Structure
- Actual Use Cases

Introduction & Motivation

- The complexities of monitoring an HPC system:
 - Layers and versions of software stack
 - System-level configurations
 - I/O components (memory, filesystem)
 - Diversity in user need and usage
 - Variable network traffic
- Performance regression may occur over time
 - requires historical data to easily detect
- **Application-level regression testing**

Aggregate
impact?

Goals

- Monitor usability and performance
- User-level experience
 - no privilege access, minimum ‘specialized’ tests
- Early detection of regressions
 - Tests are run during production period
- Automated and consistent test solution
- Store historical data
- **Solution: Jenkins Automation Server**

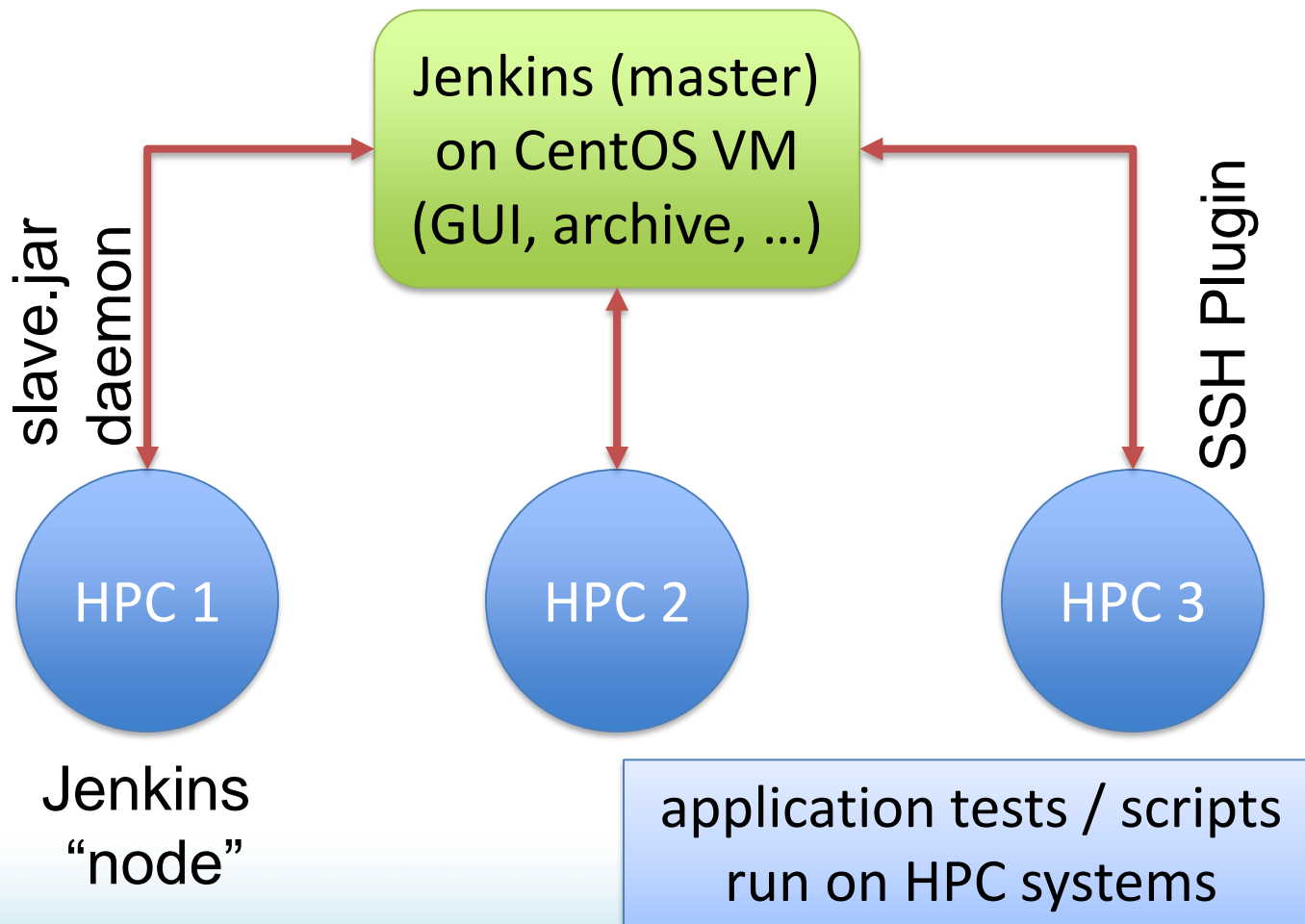
What is Jenkins?



- An “open source automation server”
- Automate user-level tasks
 - Execute arbitrary commands
 - Build software & submit jobs
 - Archive test results
 - Notify (email, text, ...) on error
- “Never sleeps or takes vacation”
- Chosen for
 - versatility
 - multitudes of plugins (plot, ssh, ...)
 - large community support

Implementation & Deployment

Basic Configuration



Accessing (Remote) HPC Test Systems

Jenkins “Node”

- Requires running “slave.jar” daemon
- Daemon connects back to master on specific port
- Remote execution appears “local”
 - no need to copy files / data
 - can access lustre, /home as if they are local resources

NICS

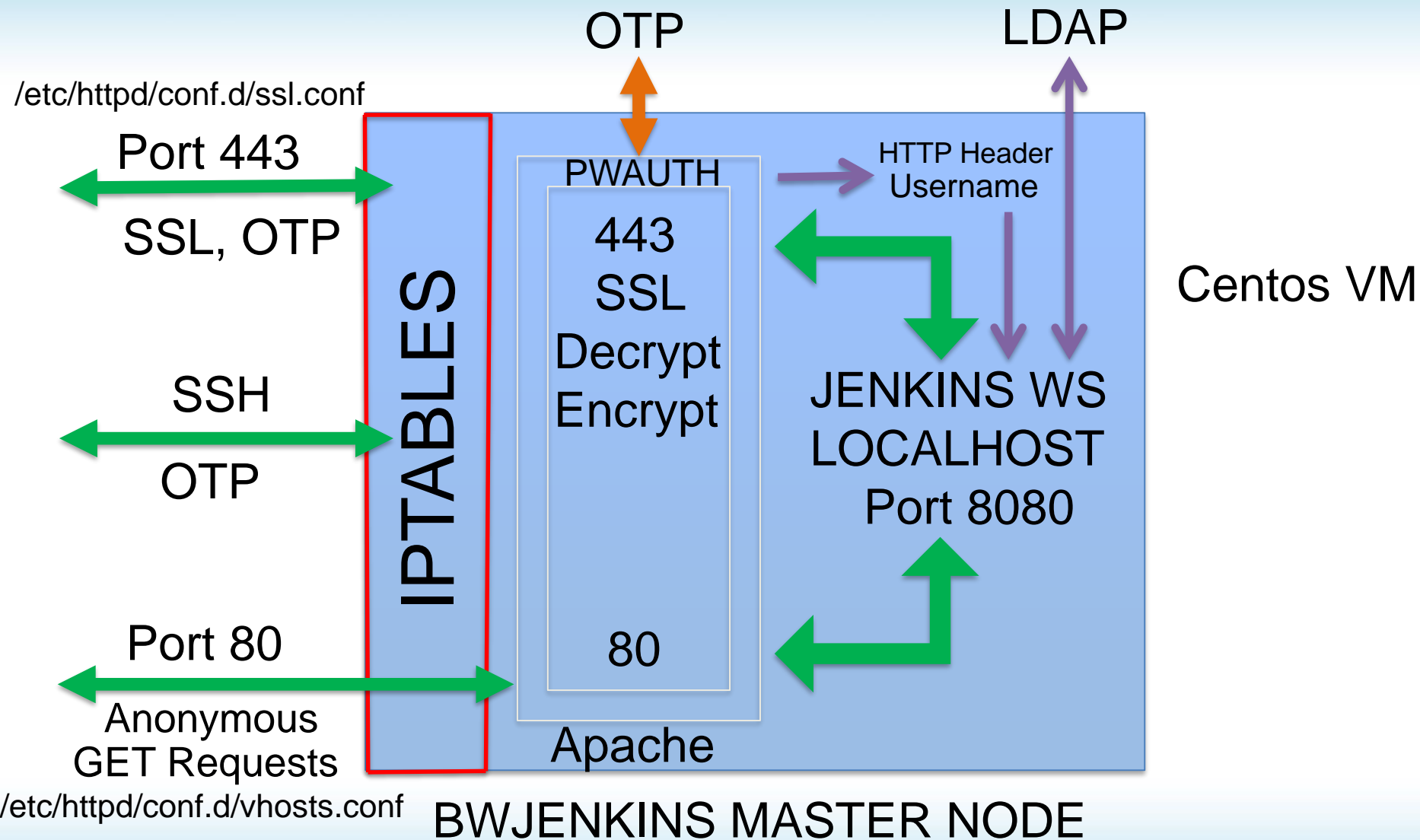
With SSH Plugin

- Need to set up passwordless login with SSH keys
- Closer resemblance to user experience
- Have to manually manage data movement (file copying, getting results back) to

NCSA

Security Considerations

- Jenkins allows execution of arbitrary command
 - use Apache HTTPD server in front of Jenkins', pass requests via mod_proxy
 - allow authenticated access only from institutional IPs via firewall rules
 - use RSA OTP for authentication via pwauth + custom session management (details in paper)
- Use LDAP for authorization with Jenkins “matrix-based” security



Jenkins Global Security

Authorization

- ☐ Anyone can do anything
- ☐ Legacy mode
- ☐ Logged-in users can do anything
- ☒ Matrix-based security



User/group	Overall	Credentials	Agent	Job	Run	View	SCM																								
	Administer	ConfigureUpdateCenter	Read	RunScripts	UploadPlugins	Create	Delete	ManageDomains	Update	View	Build	Configure	Connect	Create	Delete	Disconnect	Provision	Build	Cancel	Configure	Create	Delete	Discover	Read	Workspace	Delete	Update	Configure	Create	Delete	Read
 Sub_UTK	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 arnoldg	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 bw_admin	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 bw_seas	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 rbudiard	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Anonymous	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Application Test Structure

An Application Test: Jenkins Project

- Name and description - what is tested, frequency, resources
 - Limit number of “builds” kept - conserve server storage
 - Source code management - subversion or git
 - Build trigger - manual or automated schedule
 - Build commands – shell commands to execute test
 - Post-build Actions – generate plots, notifications on failure
- Project can be easily copied from an existing one*

Admin Gui Home Page

New Item

People ← Anonymous

Build History ← Only View

Edit View

Delete View

Log In ←

Manage Jenkins

My Views

Credentials

Build Queue

No builds in the queue.

Build Executor Status

master

- 1 Idle
- 2 Idle
- 3 Idle
- 4 Idle
- 5 Idle
- 6 Idle
- 7 Idle
- 8 **ior-h2ologin4-darshan** #197 Disabled
- 9 **MILC-BW** #705 Fail
- 10 Idle

Add JYC tests that are considered done and production-ready here with "Edit View".

[edit description](#)

All BlueWaters H2ologin4 **JYC** Post PM short tests SPP bw-new-pe +

S	W	Name ↓	Last Success	Last Failure	Last Duration	
	☀	cray-hdf5-parallel-jyc	1 day 18 hr - #48	5 mo 19 days - #21	10 min	
	☀	cuda-jyc	7 hr 45 min - #442	N/A	10 min	
	☀	HDF5Benchmarks	19 min - #2095	1 day 1 hr - #2085	58 sec	
	☀	IOR-jyc	8 hr 49 min - #613	N/A	11 min	
	☀	JobLaunch-JYC ← Select Project	50 min - #7394	1 day 2 hr - #7367	1 min 34 sec	
	☁	LAMMPS	1 day 0 hr - #2086	1 day 1 hr - #2085	46 min	
	☀	Lustre Check Ost JYC	58 min - #6992	N/A	3.9 sec	
	☀	mdtest-jyc	1 hr 58 min - #529	17 days - #496	10 min	
	☁	MILC	4 hr 45 min - #1254	14 days - #1250	31 min	
	☀	NAMD ← Pass	2 hr 44 min - #2135	14 days - #2126	29 min	
	☀	NWCHEM	22 hr - #1177	13 days - #1173	4 hr 6 min	
	☀	osu_reduce	10 hr - #418	N/A	10 min	
	☀	Qstat JYC	38 min - #8032	N/A	3.9 sec	
	☀	stream-xe-jyc ← Disabled	12 hr - #445	26 days - #397	10 min	
	☀	testexternaljob	N/A	N/A	N/A	
	☁	TestSSH-JYC ← Fail	2 days 4 hr - #21	1 day 2 hr - #25	6 sec	

Schedule a Build →

Project View

Jenkins
BlueWaters
JobLaunch-BW

Back to Dashboard
 Status
 Changes
 Plots

Historical Plots

Build History
[trend](#)

#7718

Apr 27, 2017 6:57 PM

#7717

Apr 27, 2017 5:57 PM

#7716

Apr 27, 2017 4:57 PM

#7715

Apr 27, 2017 3:57 PM

Build Details

Project JobLaunch-BW

Job Launcher Test to Compare Wrapped (XALT) Aprun to Real Aprun on

Tests : environment , xalt , aprun

[Recent Changes](#)

Permalinks

- [Last build \(#7718\), 23 min ago](#)
- [Last stable build \(#7718\), 23 min ago](#)
- [Last successful build \(#7718\), 23 min ago](#)
- [Last failed build \(#7677\), 1 day 17 hr ago](#)
- [Last unsuccessful build \(#7677\), 1 day 17 hr ago](#)
- [Last completed build \(#7718\), 23 min ago](#)

Example Console Log

Jenkins ▸ BlueWaters ▸ JobLaunch-BW ▸ #7718

- Back to Project
- Status
- Changes
- Console Output** Select
- View as plain text
- View Build Information
- Previous Build

Console Output

Started by timer
Building on master in workspace /var/lib/jenkins/workspace/Jc
Updating <https://github.com/reubendb/SWTools-BWCI/trunk/jobla>
At revision 22

No changes for <https://github.com/reubendb/SWTools-BWCI/trunk>
[JobLaunch-BW] \$ /bin/sh -xe /tmp/jenkins125936332362860387.s
+ rsync -az --delete -e ssh /var/lib/jenkins/workspace/JobLav
/bwjenkins/tests/

Access by OTP or Two Factor Certificate Authority only.
Use myproxy-logon -s tfca.ncsa.illinois.edu -p 7512 for gsis
gsissh or ssh -o PreferredAuthentications=keyboard-interactiv

Blue Waters Admin Team
executing script:
SW_CONFIG="/scratch/system/bwjenkins/sw_config"
PATH="/sw/tools/bin:/sw/tools/bin:\$PATH"
PYTHONPATH="/sw/tools/bin:/sw/tools/bin:\$PYTHONPATH"
SW_ROOT="/scratch/system/bwjenkins/tests"

IOR-bluewaters

Would last have run at Thursday, May 11, 2017 7:53:34 AM CDT; would next run at Thursday, May 11, 2017 1:53:34 PM CDT.

☐ Poll SCM

Build Environment

☐ Execute shell script on remote host using ssh

Build

Execute shell script on remote host using ssh

SSH site

bwjenkins@bw.ncsa.illinois.edu:22

Command

```
module load autoconf
module load automake
~/bin/myenv.sh
rm -rf jenkins-lor/
mkdir jenkins-lor
cd jenkins-lor
git clone https://github.com/LLNL/lor
cd lor
./bootstrap
./configure --host=x86_64 CC=cc
make -j 4
file src/lor
ls -l src/lor

cp src/lor ~arnoldg/lor/src/lor
#make clean; make
cat -n ~arnoldg/lor/compare_stripe.pbs # there is a lorchscript input file for lor in the same directory
MYJOBID=`qsub ~arnoldg/lor/compare_stripe.pbs`
echo MYJOBID=$MYJOBID
~/bin/wait_for.sh $MYJOBID

echo "=== JOB RAN ON ==="
cat ~/scratch/stripe8/lor-compute-nodes
if [ -f ~/scratch/stripe8/lor-compute-nodes ]
then
: # It's all good
else
echo "lor-compute-nodes not found, pbs job likely hit walltime"
exit 1
```

Test Script

Save

Apply

Use Cases

Project Failure Email Notification

See <http://bwjenkins.ncsa.illinois.edu/job/Lustre_Check_OST_BW/7218/display/redirect>

Started by timer

Building on master in workspace <http://bwjenkins.ncsa.illinois.edu/job/Lustre_Check_OST_BW/ws/>
executing script:

SW_WORKDIR="/scratch/system/bwjenkins/sw_workdir"

JOB_NAME="Lustre_Check_OST_BW"

**snx11003-OST010c-osc-ffff885fc0cd3c00: check error:
Resource temporarily unavailable**

[SSH] exit-status: 255

Build step 'Execute shell script on remote host using ssh' marked build as failure

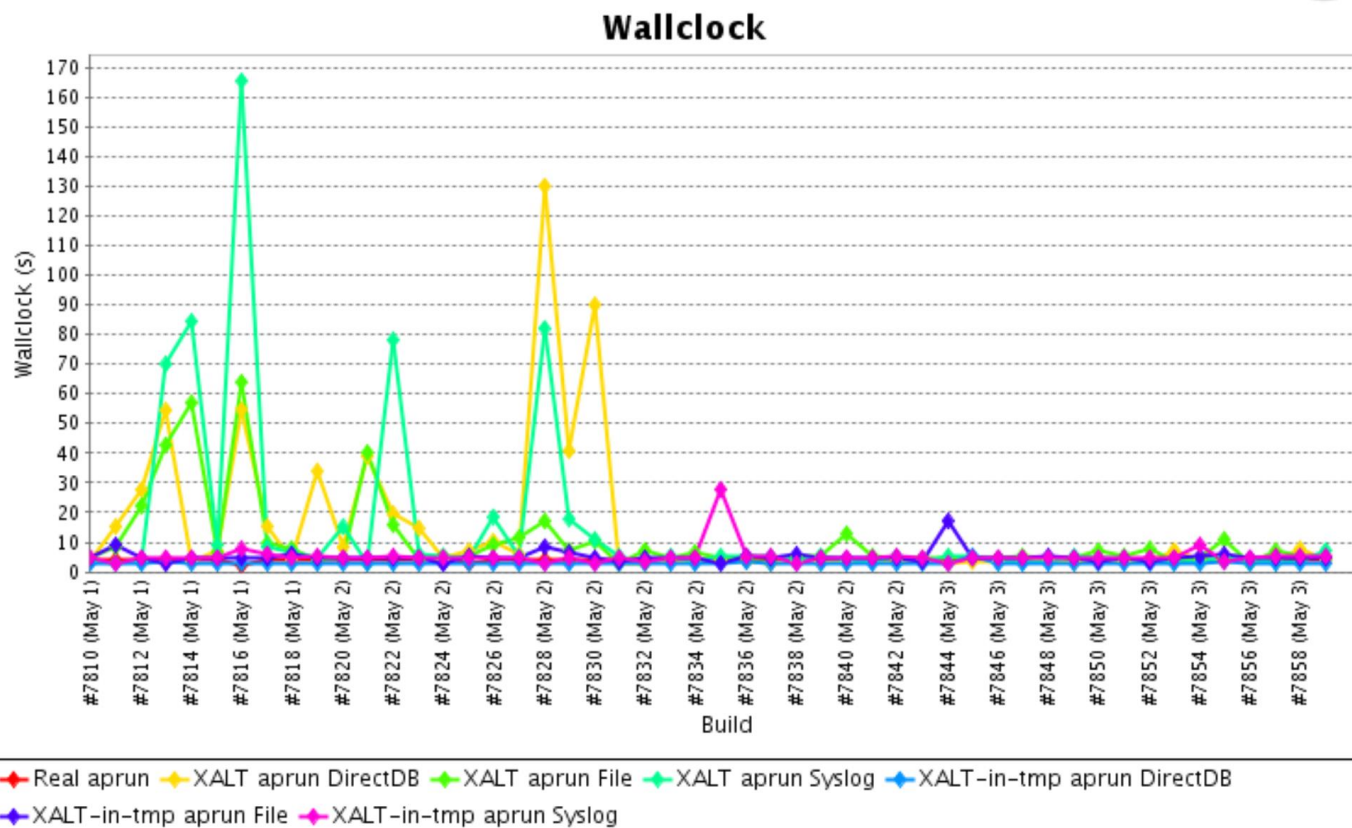
Recording plot data

Saving plot series data from:

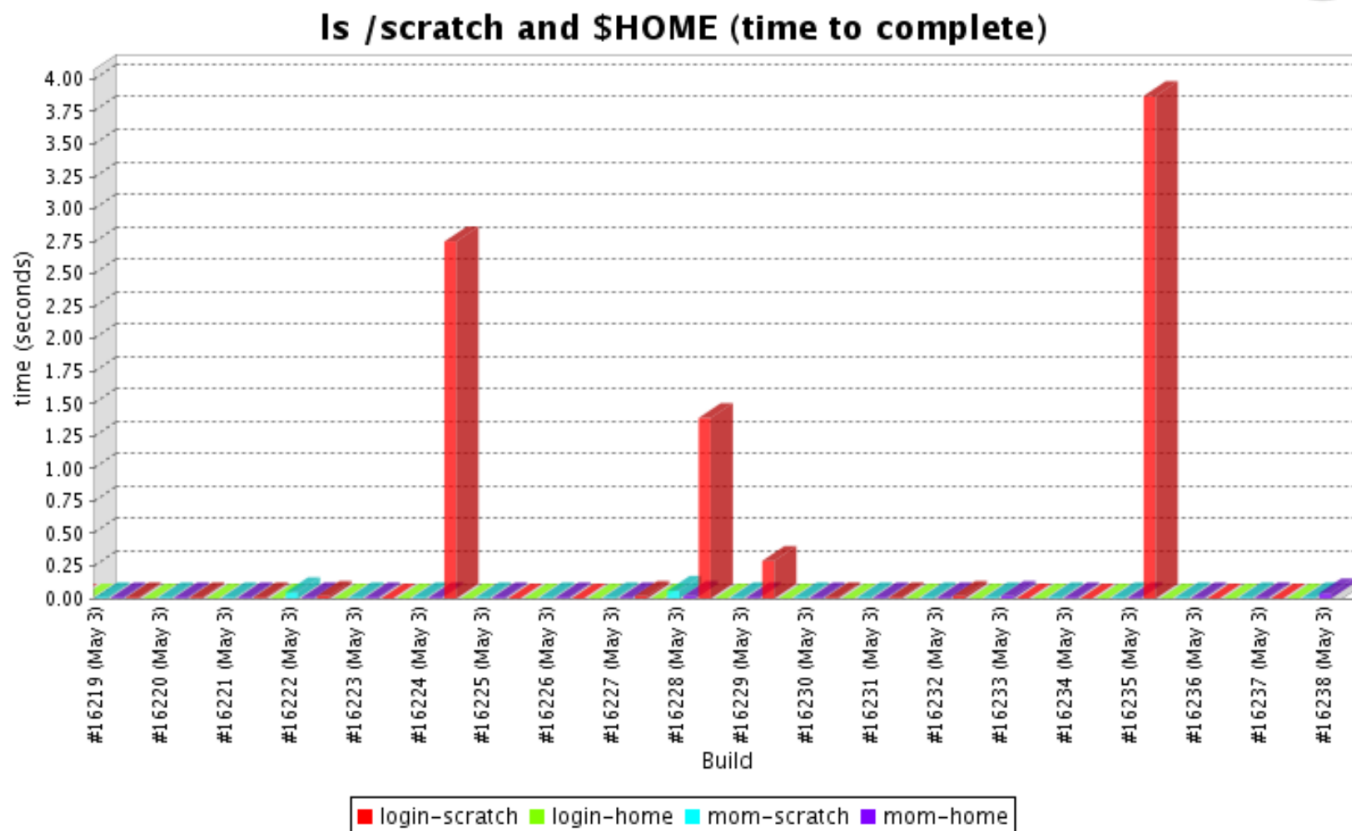
<http://bwjenkins.ncsa.illinois.edu/job/Lustre_Check_OST_BW/ws/bw_active>

Slow JobLaunch-BW Plot

[↑ top](#)

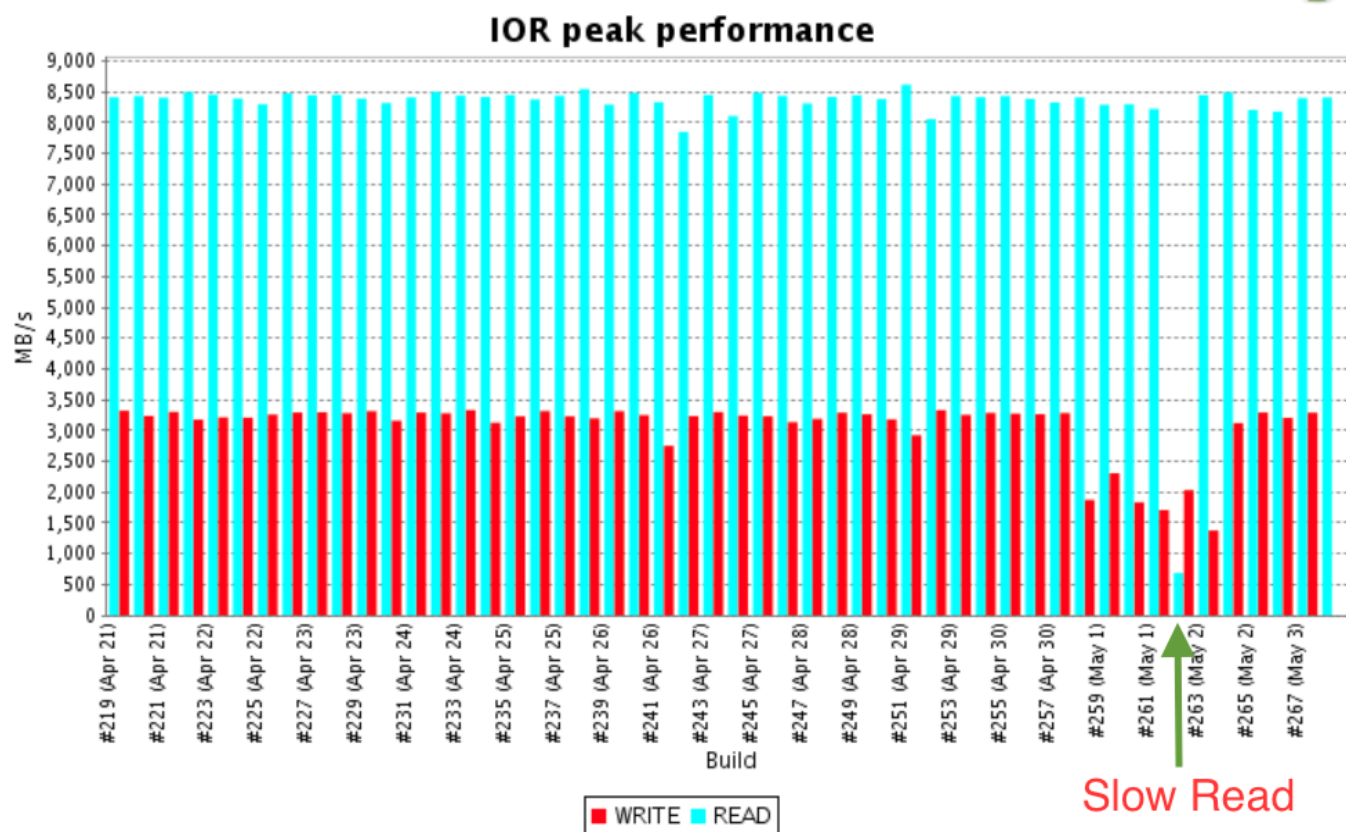


Slow Lustre Scratch from a login node



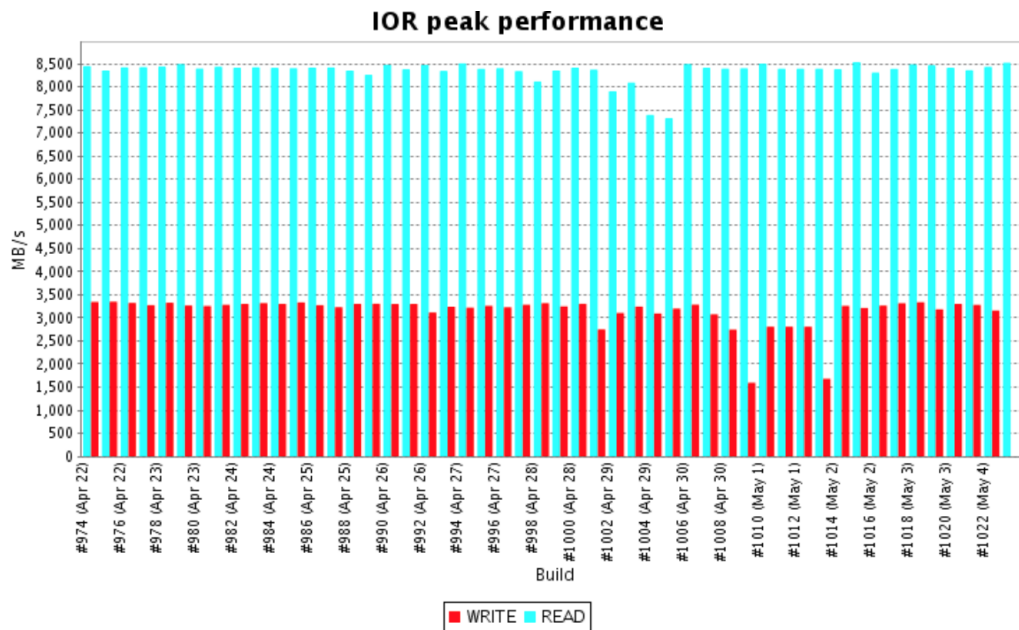
Slow IOR-login Test Example

[↑ top](#)



IOR-BlueWaters test failures

Build History		trend
find	x	
#1023	May 4, 2017 1:53 PM	
#1022	May 4, 2017 7:53 AM	
#1021	May 4, 2017 1:53 AM	
#1020	May 3, 2017 7:53 PM	
#1019	May 3, 2017 1:53 PM	
#1018	May 3, 2017 7:53 AM	
#1017	May 3, 2017 1:53 AM	
#1016	May 2, 2017 7:53 PM	
#1015	May 2, 2017 1:53 PM	
#1014	May 2, 2017 7:53 AM	
#1013	May 2, 2017 2:41 AM	
#1012	May 1, 2017 7:53 PM	

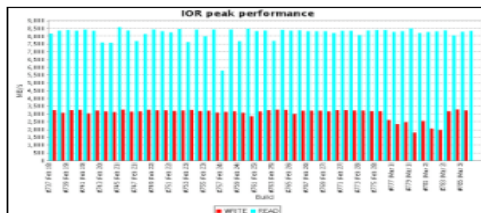


Two Failed Tests that went over 10 minute wallclock.
These failures indicate an issue with the filesystem.

Plot Usage : Wiki Filesystem dashboard

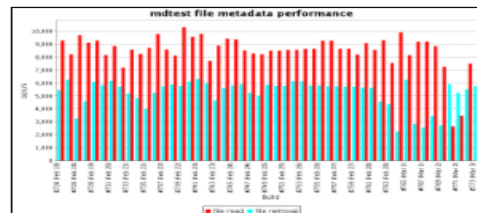
Jenkins Monitoring, see also : <http://bwjenkins.ncsa.illinois.edu/view/BlueWaters/>

scratch



higher is better.

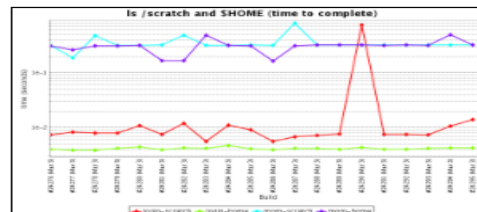
If low only once, build might have used busy OSTs.



higher is better.

Trouble if mdtest and IOR rates are both low.

scratch and \$HOME is test

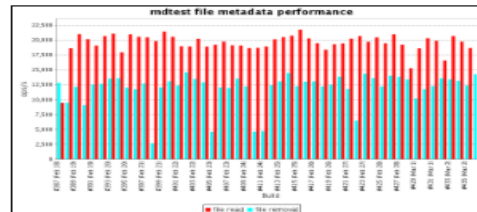


Low is better. This is a good measure of how the filesystem "feels" to users. Times < 1.0s are generally good. These tests are on a 5 minute interval so this graph is approximately the last hour's performance.

home

No IOR testing:

We don't do large block i/o on \$HOME.



higher is better.

Conclusion

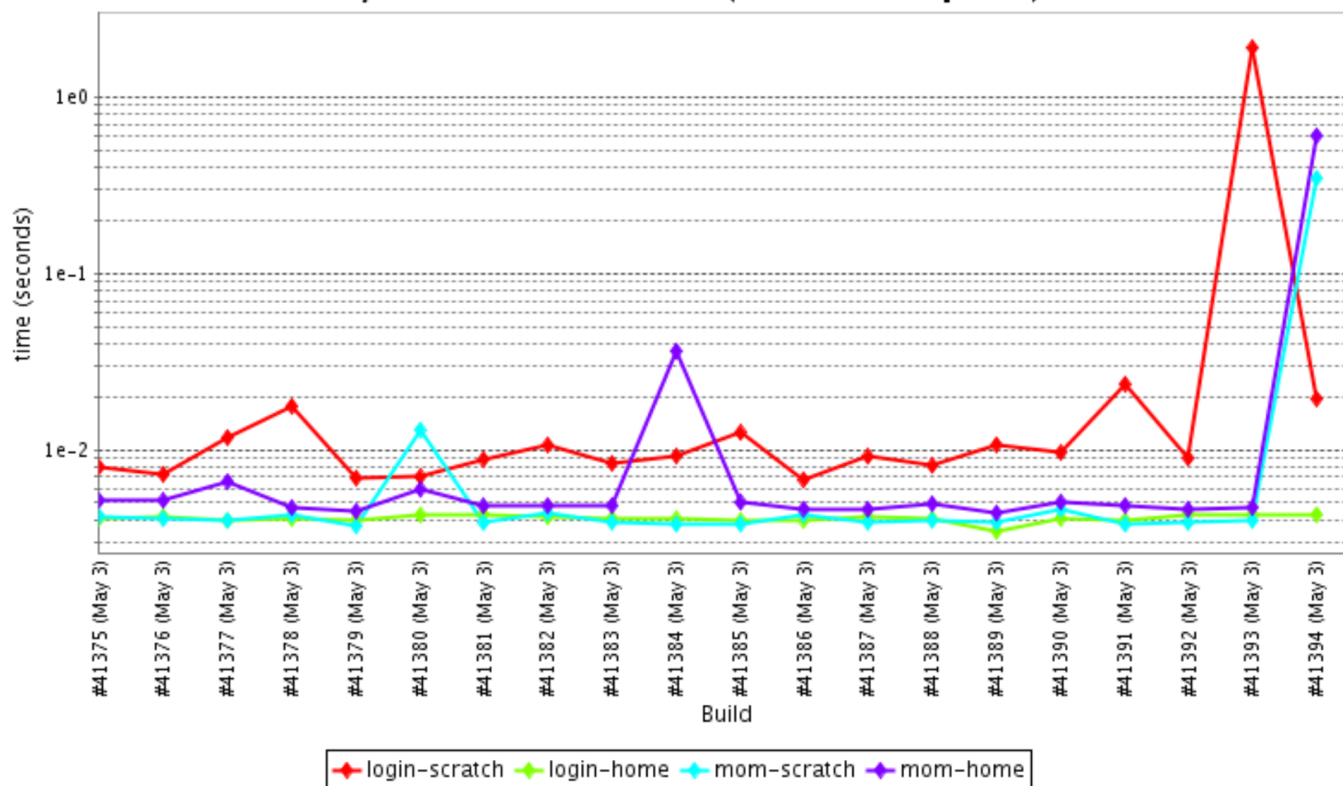
- Regression testing framework, enabling:
 - Reproducibility of tests
 - Regression testing
 - Rapid reaction ← more tests are added as needed
- Has been deployed at
 - Blue Waters at NCSA
 - NICS
 - Compute and Data Environment for Science (CADES) at ORNL (in progress)
- Future work: integrate with other change managers



Delete?



Is /scratch and \$HOME (time to complete)



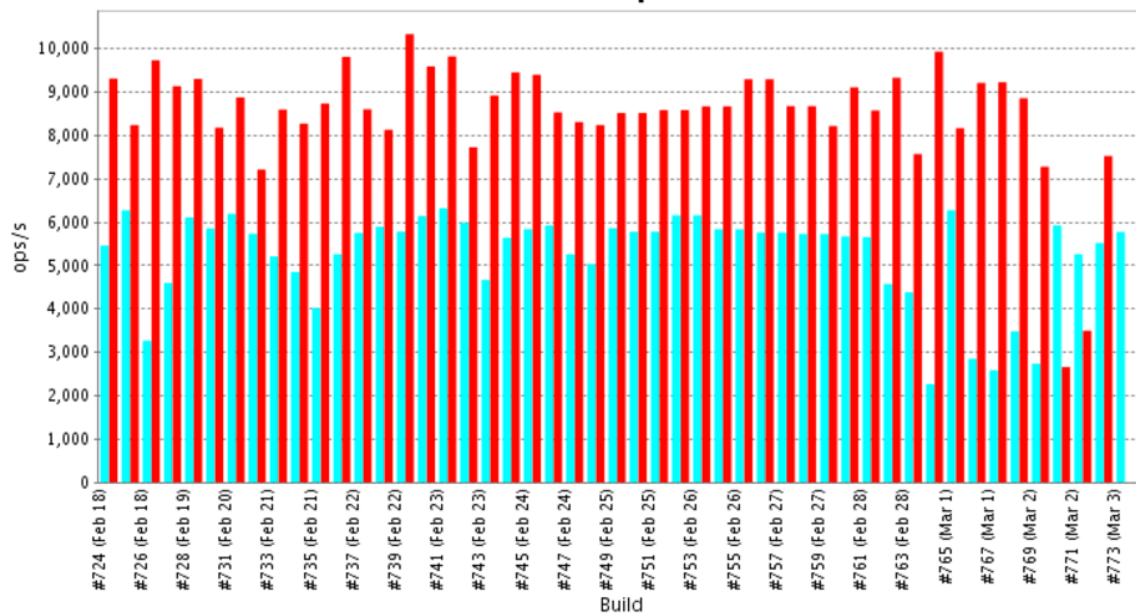
Delete Mdtest Test plot



Jump to ↕

[↑ top](#)

mdtest file metadata performance



Acknowledgements – delete?

- Special thanks to
 - Galen Arnold NCSA – test integrator
 - Rueben Budiardja NICS – Jenkins install/configuration and test integrator
 - Gary Rodgers NICS – httpd configuration

Delete? Master Node Configuration

- Centos 6.8 virtual machine
- Physical access restricted to OTP secure server
- Installed Jenkins
- Configured jenkins behind apache
- Generated unique ssh keys (var/lib/jenkins/.ssh)
- Jenkins GUI – Manage Jenkins; Configure System
 - SSH remote hosts section
 - Add hostname; Port; Username (for each client resource)
 - sshkey Passphrase; Keyfile location (on server)

Delete? Usability Impacts

- CRAY Programming Environment Updates
- System and Third Party Software Updates
- Scheduled Maintenance
- Weekly warm hardware swaps
- Lustre Degradation Issues
- User workload interactions
- Environment (power & cooling)

Delete: Master Node Apache & OTP

- Default Jenkins web server port 8080
- `/etc/sysconfig/jenkins JENKINS_LISTEN_ADDRESS=127.0.0.1`
- `/etc/httpd/conf.d/ssl.conf`
 - `ProxyPass / http://localhost:8080/ nocanon`
 - `ProxyPassReverse / http://localhost:8080/`
 - `ProxyPassReverse / http://bwjenkins.ncsa.illinois.edu/`
 - `RequestHeader set X-Forwarded-Proto "https"`
 - `RequestHeader set X-Forwarded-Port "443"`
- Installed `mod_authnz_external` native package
- `/usr/local/bin/pwauth+session: https://github.com/reubendb/BasicAuthOTPSession/blob/master/BasicAuthOTPSession.py#L1`

Delete- Jenkins Demo?

<http://bwjenkins.ncsa.illinois.edu>