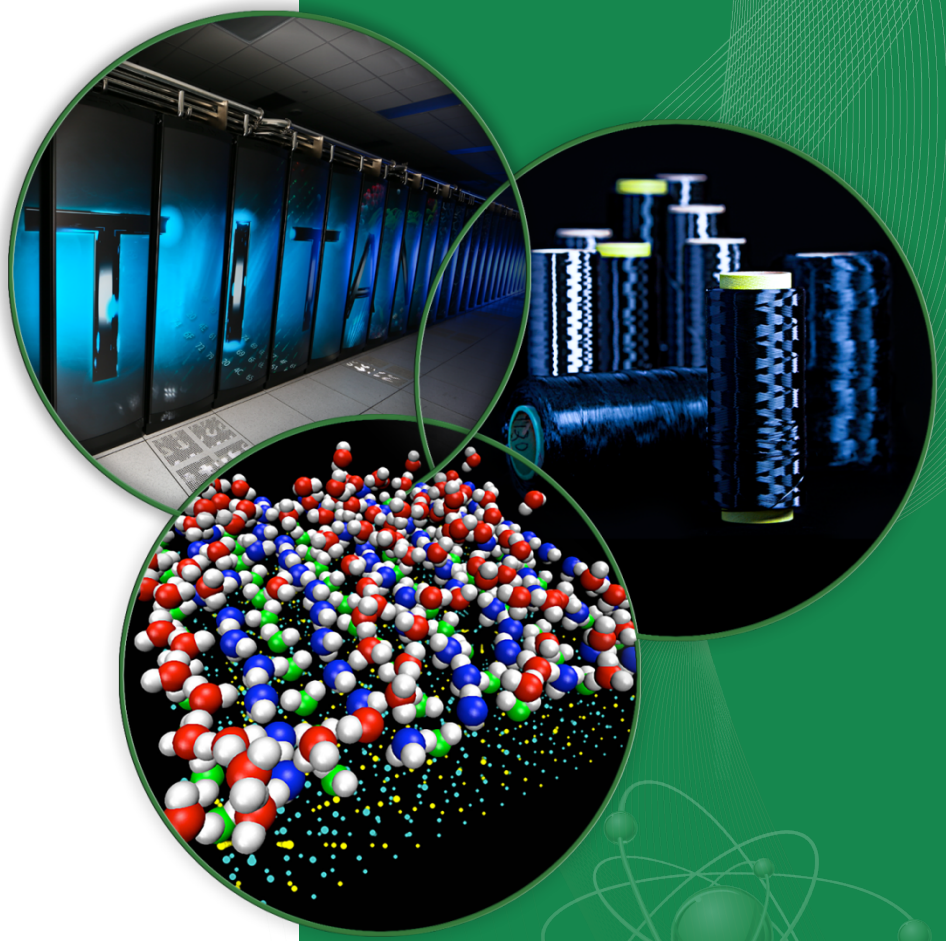
Use of Continuous Integration Tools for Application Performance Monitoring



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Overview

- **Part 1:** Background & Motivation
- **Part 2:** Application Performance Monitoring
- **Part 3:** Environment Monitoring

Part 1:

Background

Background & Motivation

- High performance computing systems are increasingly complex
  - Hardware (HW) and software (SW) stack
- How to measure impact of HW/SW changes?
  - Performance of applications, user environment stability
- **Proposed solution:** Application level monitoring system
  - *Often:* develop a tool from scratch
  - *Another option:* use/repurpose well-supported existing tools (no need to reinvent the wheel!)

Background & Motivation

- Many tools available from a system administration perspective
  - Nagios, Ganglia, Cray's Node Health Checker, etc
  - Help detect failures with systems and services
- Sustained system performance monitoring
  - NERSC's SSP metric, DoD's monitoring system
  - Detect performance degradation using benchmarks and applications
- In-house tools often developed
  - Significant center resources needed to maintain
- CI tools already provide most of the features needed to monitor performance and stability

CI vs. Monitoring workflow

CI workflow

- *Target:* software project
- Test, test, test
- After every commit:
  - Build software
  - Run set of tests
- Test on a regular schedule
- Alert when failures occur

Monitoring workflow

- *Many targets:* scientific application, benchmark, environment test
- After system software upgrade:
  - Build application
  - Submit job
- Run regularly to track performance over time
- Alert when failures occur
- Alert when performance degradation observed

Requirements

Tool

- Open source
- Freely available
- Recent release and/or bug fixes available
- Well-supported
- Flexible
- Portable
- Easy to deploy
- Minimal amount of customization needed to fit the workflow

Monitoring Workflow

- Graphical user interface
- Full job control
- Interactive dashboard
- Configurable analysis and plotting
- Reporting capabilities
- Customizable notifications
- Security features available
- Archiving capabilities
- Resilient to failures

CI Tools Evaluated

- Started with popular CI tools
- Grouped tools into:
  - commercial vs. freely available
  - closed vs. open source
  - hosted vs. deployable
- Top FOSS contenders: Jenkins, Buildbot, Continuum, Go
- Commercial/paid: TeamCity, Bamboo, Travis CI

CI Tools Evaluated (cont'd)

Tool	License	Latest Release	Dashboard	Features	Plugins	Plotting
Buildbot	GPL	Dec 2014	✓	Launch, report	10s	✗
Continuum	Apache 2.0	Jun 2014	✓	Full-control	10s	✗
CruiseControl	BSD-style	Sep 2010	✓	Launch, report	10s	✗
Go	Apache 2.0	Jan 2015	✓	Launch, report	10s	✓
Jenkins	CC & MIT	Jan 2015	✓	Full-control	> 1,000	✓
Travis CI	MIT	Oct 2014	✓	Report		
TeamCity	Proprietary	Jan 2015	✓	Full-control		✓
Bamboo	Proprietary	Nov 2014	✓	Full-control		✓

Why Jenkins?

- Large user community behind it
  - Over 100,000 users
- Provides full job control and management
  - Interactive dashboard
  - Flexible job scheduling
- Extensible with over a thousand plugins
- Plotting and reporting capabilities
- Customizable views
- Robust notification capabilities

Part 2:

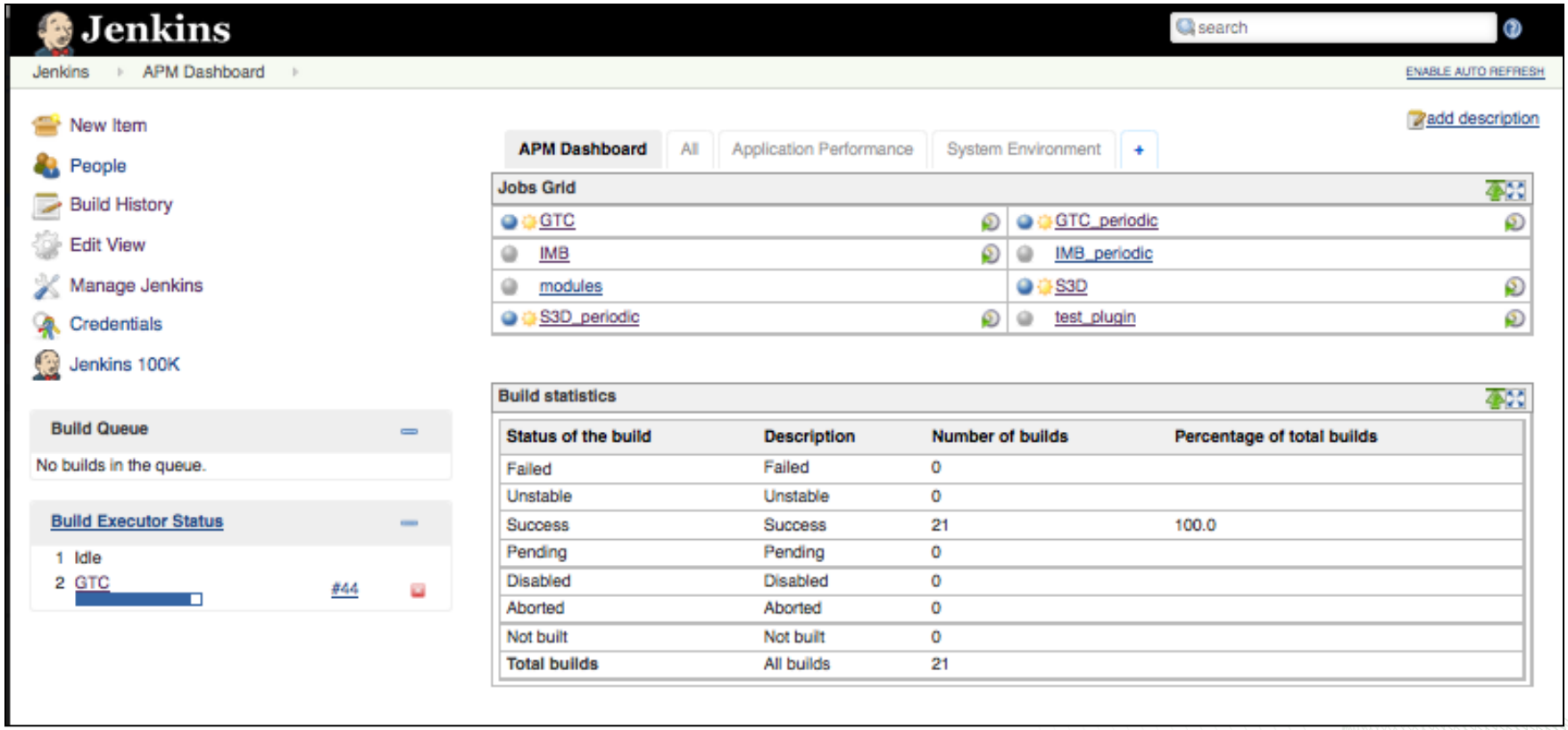
Application Performance Monitoring

Jenkins initial setup

- The Jenkins application is easy to download, launch with Java
- User can access Jenkins through a web browser interface
- Installed Plot plugin, Parametrized Trigger plugin, LDAP plugin, Dashboard View plugin, AnchorChain plugin
- Set up as two directories:
  - Jenkins install directory
  - Supporting scripts directory
- Scripts directory is stored in git repo
- Jenkins configure files for defining dashboards and build targets stored also in scripts directory for version control

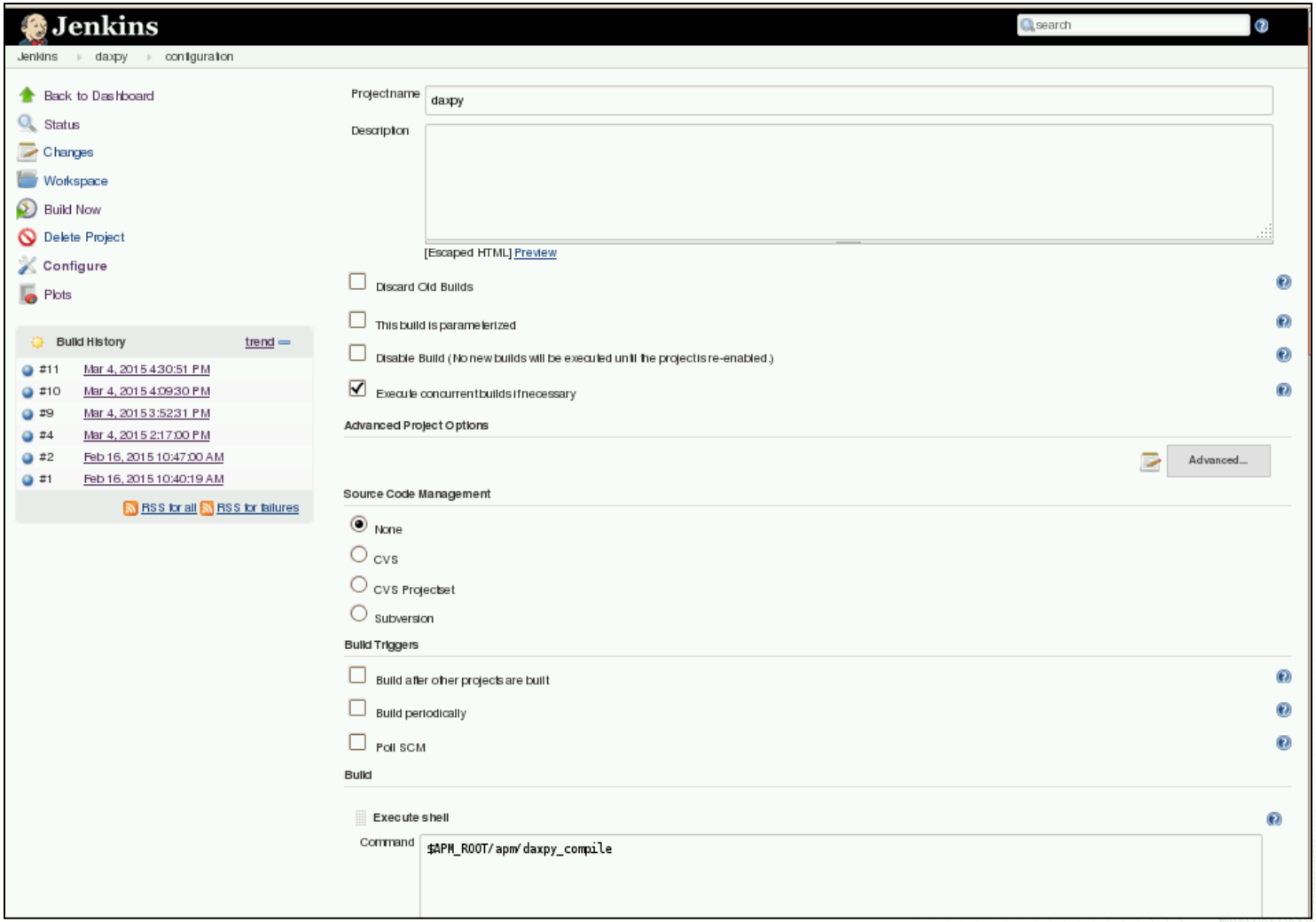
Jenkins dashboard

- Main dashboard presents list of executable build targets on right
- Left panel shows status of builds currently being executed
- “build” here can be a software build or any executable operation



Jenkins build targets

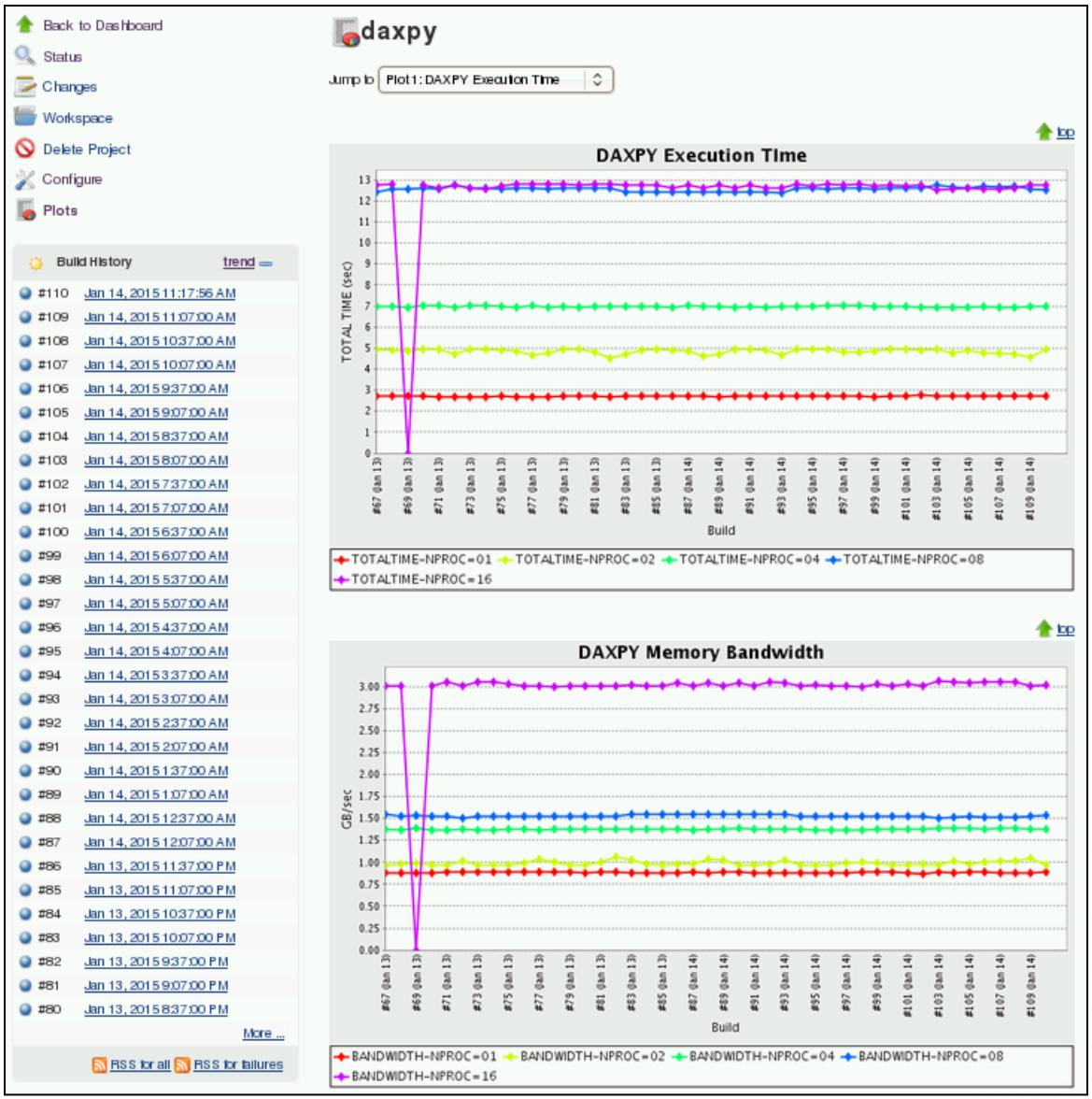
- Configure page used to configure the operations to perform a build



Example: DAXPY

- Test case: execute DAXPY kernel on 1-16 cores of a single node
- Shell script 1: create and compile executable
- Shell script 2: create and submit PBS scripts to run executable and collect timing results to files; spin loop to wait for PBS jobs to complete
- Settings on Jenkins DAXPY build configure page:
  - Execute two scripts
  - Run Plot plugin on results
  - Set up to run periodically with cron-like syntax
- Then can launch single DAXPY run or start periodic runs from the DAXPY dashboard
- For any build instance, user can view execution status on main page; can view job console output in real time if desired; can later access build artifacts for further inspection

DAXPY results

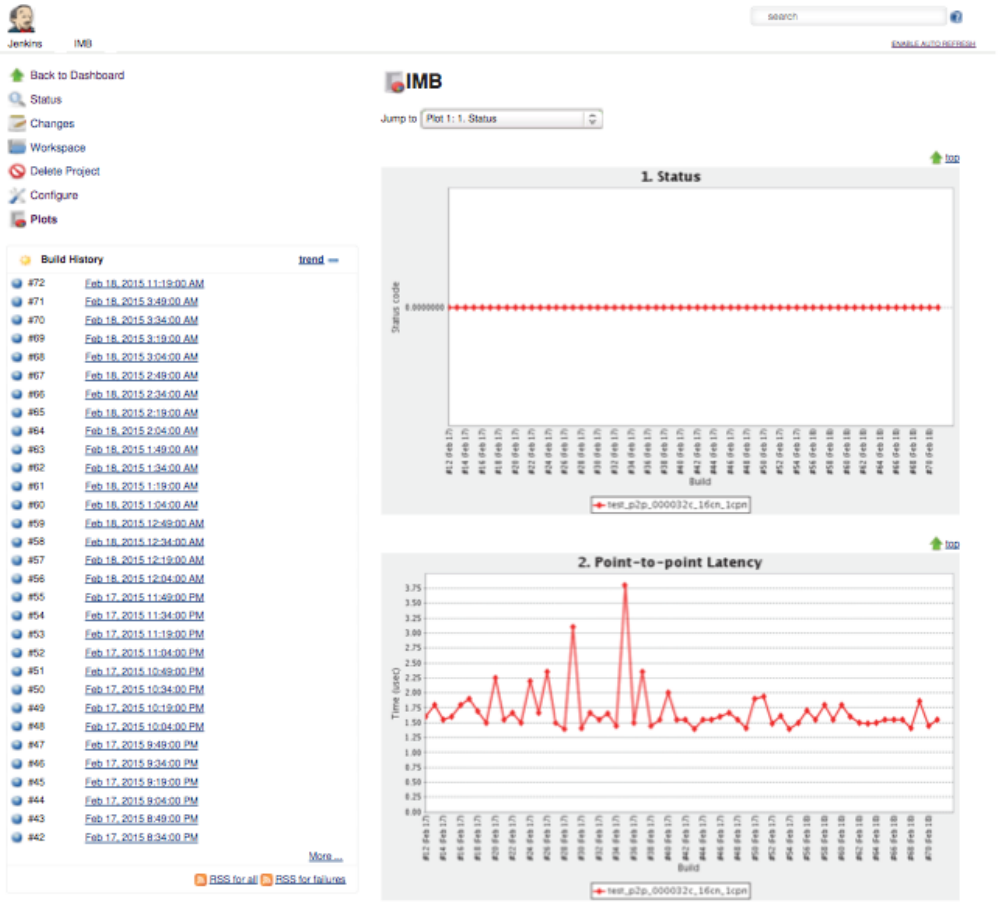


Example: application harness code

- OLCF has an application test harness, used for acceptance testing and IO system testing
- Has two parts:
  - Harness code proper – schedules and monitors builds and runs of applications
  - Harness applications – defines build and execution procedures for selected applications
- Each harness application instance has several scripts:
  - build_executable.x – compile the code
  - submit_executable.x – create PBS script and submit
  - check_executable.x – check run results for correctness
  - report_executable.x (NEW) – extract run metrics of interest
- Two “coupling” scripts were written to interface the already-existing large set of harness applications to Jenkins:
  - harness_build – build the code
  - harness_submit – submit the run, spin loop until completion, collect results

Harness example: IMB

- Simple run of Intel MPI Benchmarks suite to perform ping-pong test
- Used existing harness code as-is, only needed to add report_executable.x file to extract latency/bandwidth metrics from IMB output file



An alternative: Splunk

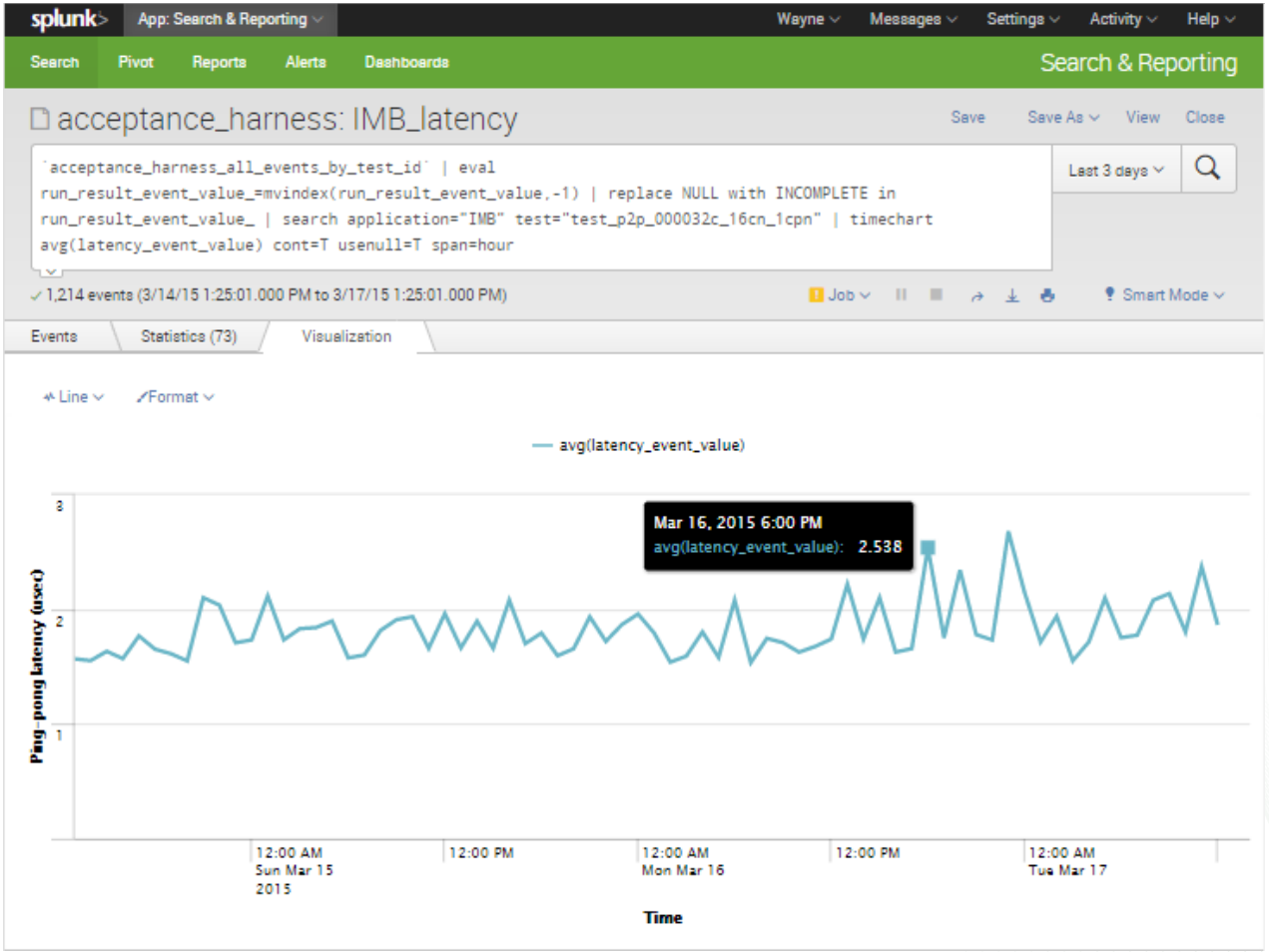
- Our experience with Jenkins indicated the plot capabilities were not as flexible as would be desired
- We also wanted to be able to visualize results from runs initiated by the existing harness, which is not straightforward for Jenkins which wants to own the build process
- Investigated the Splunk log monitoring tool as an alternative
- Does not satisfy all our original requirements, e.g., regarding job management, but has superior reporting capablities

Splunk: Implementation

- Used the install of Splunk already in use in the center
- Made small changes to the harness to write key events to system log, e.g., build/submit/run begin/end events
- Modified report_executable.x for harness applications to write metrics of interest to the system log, appropriately tagged
- Wrote Splunk code to collect these events, group by application run instance
- Splunk reports and dashboard implmented to present results of application runs over time

Splunk example: IMB

- Used the same IMB example described previously
- Ran in the harness, used Splunk to collect and display results



Part 3:

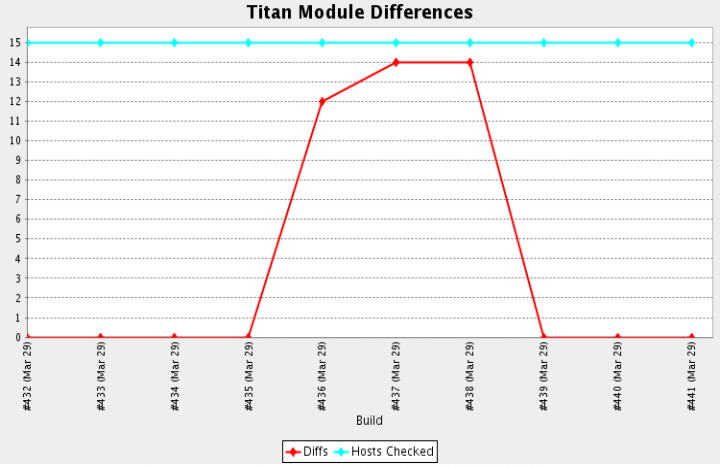
Environment Monitoring

Environment Monitoring

- Large number of environment variables, modules, tools that can impact system use
- Environment changes can be just as impactful as performance changes
- Many environment triggers are behind scenes and not known to most users
- Staff members have ability to change environment
  - Small change: *should not impact anyone*
  - Software installs become defaults
- Verify consistent standard environments between systems, login nodes, and over time
- Examples:
  - Ensure modules same across login nodes
  - Find changes in a system's default modules over time
  - Ensure batch job submissions follow system's batch policies
  - Ensure pre-defined set of tools and environment variables exist on each system
  - Verify ability to send/retrieve data between the HPSS and Data Transfer Nodes

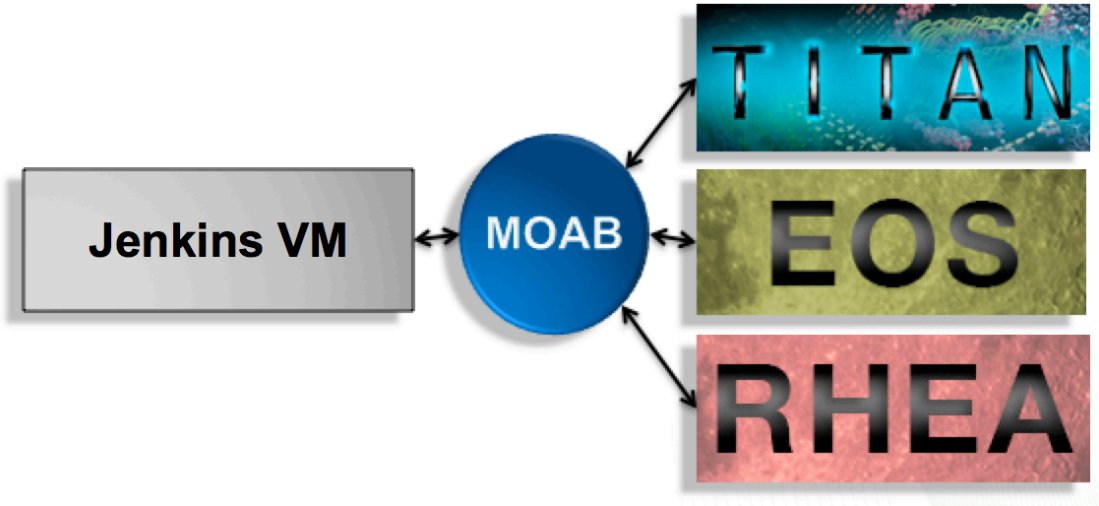
Module Monitor Example

```
See <http://localhost:8080/job/common_modules_within_system/438/>
----------------------------------------
Started by user anonymous
Building in workspace <common_modules_within_system/ws/>
[titan] $ /bin/sh -xe /tmp/hudson3903209286972211677.sh common_modules_within_system/bin/run_test_titan
[[10:47:41 3-29][submit_batch:main:202]] Checking for lockfile: <common_modules_within_system/ws/lockfile>
[[10:47:41 3-29][submit_batch:main:546]] Creating file: <common_modules_within_system/ws/lockfile>
[[10:47:41 3-29][submit_batch:main:528]] Creating batch file
[[10:47:41 3-29][submit_batch:main:546]] Creating file: <common_modules_within_system.pbs>
[[10:47:41 3-29][submit_batch:main:614]] Removing <common_modules_within_system/ws/batch-started>
[[10:47:41 3-29][submit_batch:main:614]] Removing <common_modules_within_system/ws/batch-completed>
[[10:47:41 3-29][submit_batch:main:335]] Submitting batch job
[[10:47:41 3-29][submit_batch:main:344]] Job submitted: 2305631
[[10:47:41 3-29][submit_batch:main:370]] Waiting on batch job to start
[[10:48:41 3-29][submit_batch:main:377]] Batch job started
[[10:48:41 3-29][submit_batch:main:413]] Waiting on batch job to complete
[[10:51:41 3-29][submit_batch:main:420]] Batch job completed
[[10:51:41 3-29][submit_batch:main:614]] Removing <common_modules_within_system/ws/lockfile>
[[10:51:41 3-29][process_results:main:27]] Processing results: Begin
[[10:51:41 3-29][process_results:main:56]]
HostsTested,15
ModuleDiffs,14
ModulesTested,225
ModuleVersionsTested,369
Miss Details:
VirtualGL(3):ERROR:106: missing on titan-ext4 titan-ext5 titan-ext1 titan-ext6 titan-ext3 titan-ext2
titan-ext7 Found on titan-login8 titan-login5 titan-login6 titan-login7 titan-login2 titan-login4
titan-login3 titan-login1
...
[ERROR][[10:51:41 3-29][process_results:main:73]] Module differences found: 14
Died at common_modules_within_system/bin/process_results line 289.
Build step 'Execute shell' marked build as failure
Recording plot data
```



Throwing a wrench in the works – Two factor authentication

- Center requirement
  - System Access
  - Prevents automated ssh
  - Limits plug-ins
- BioUno's PBS plug-in
- Center-wide batch system
  - Already in place to enable user workflows
  - Provides ability to submit batch jobs between OLCF user systems
    - qsub between Titan, Data Transfer System, Pre/Post Processing and Analysis
    - Jenkins can also use to access OLCF user facing systems
  - Replace ssh with qsub
  - All work must go through batch system
    - Compute jobs, Compiles, Environment checks



Center-wide Batch Access

- Must manage batch jobs
  - ssh returns once task completes or fails
  - qsub returns immediately
    - Given task may not start for minutes, hours, days
  - Do not want to load queue with multiples of same test
    - Often batch system accepts jobs when target system unavailable
- Methods to track batch job progress
  - Testers need ability to submit work to batch system and wait until batch job completes
  - Provide language independent functionality to testers (script, plugin)
  - Two methods tested:

1. Poll Queue

- qstat, showq
- Straightforward
- Queue polling issues?
  - Load
  - Communication timeouts

2. Monitor Files

- Utilize center-wide filesystems
- Reduce batch polling load
- Provides additional insight into job progress
- Control time allowed for each step

Conclusions

- Cron concern, but tool is more than cron
- Allows us to visually organize and list tests
  - Can see big picture and holes in testing
- Known tool
  - Security, infrastructure, staff already familiar
  - Reduce barrier for others to contribute
- Not Jenkins experts, still plugins/features to investigate
- Jenkins has already proven to be beneficial; we will continue to add tests and investigate additional plugins

Acknowledgements

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Questions?

Thank you!