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)

<table>
<thead>
<tr>
<th>Tool</th>
<th>License</th>
<th>Latest Release</th>
<th>Dashboard</th>
<th>Features</th>
<th>Plugins</th>
<th>Plotting</th>
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<td>Launch, report</td>
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<td>Nov 2014</td>
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<td>Full-control</td>
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</tr>
</tbody>
</table>
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

DAXPY Execution Time

DAXPY Memory Bandwidth
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 capabilities
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 implemented 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:335] Submitting batch job
[10:48:41 3-29][submit_batch:main:413] Waiting on batch job to complete
[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
...
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!