



buildtest: Software Stack Testing Framework

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Shahzeb Siddiqui



- ▶ Position: HPC Engineer at Pfizer
- ▶ 5+ Years in High Performance Computing (HPC)
- ▶ Responsible for managing the application infrastructure
- ▶ Resolve user issues and conduct periodic training sessions

- ▶ MS in Computer Science – HPC from KAUST
- ▶ BS in Computer Engineer from Penn State University

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Installing software in HPC

- ▶ User request to install software in HPC cluster
- ▶ HPC Engineer must do following
 - Download installer file
 - Read Documentation
 - Install application & dependencies
 - Create Module File
- ▶ Application Build Framework
 - Easybuild – <https://easybuild.readthedocs.io/en/latest/>
 - Spack – <https://spack.readthedocs.io/en/latest/>
 - OpenHPC: <http://openhpc.community/>

Nature of Scientific Software

- ▶ Scientific Software depend on the following
 - GLIBC version
 - Operating System
 - Instruction Set Architecture – Vectorization Flags (SSE, AVX, AVX2, AVX512)
 - Compiler and MPI wrapper
 - System Packages
- ▶ Many configuration options
- ▶ Require a SME to properly build and tune software for their site

<https://developers.redhat.com/blog/2016/02/17/upgrading-the-gnu-c-library-within-red-hat-enterprise-linux/>
<https://access.redhat.com/solutions/3251421>

Common Issues with supporting scientific software

- Time consuming (days, weeks)
- Extremely hard to maintain
- Fulltime job
- Require dedicated team (5–10 SMEs)
- Lack of user documentation
- No way to automate test for entire software stack

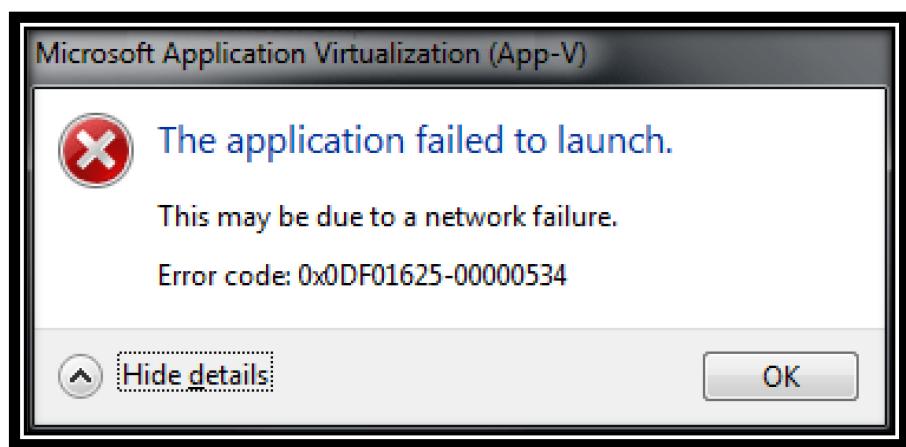
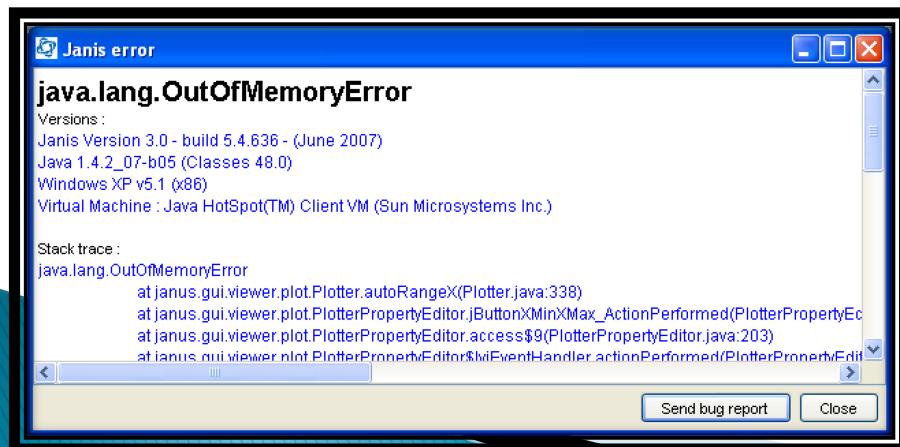
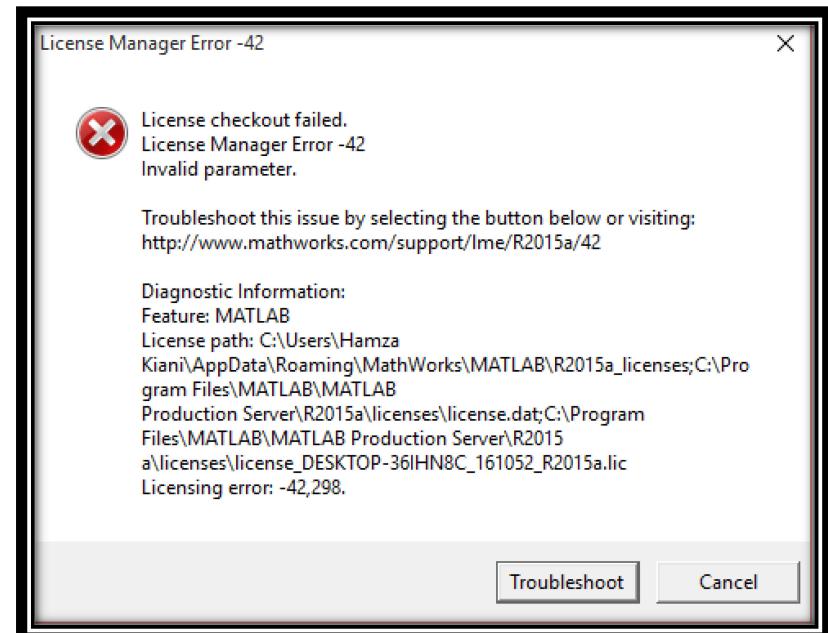
Please fix my application

Python Shell

```
File Edit Shell Debug Options Windows Help
Python 3.1.1 (r311:74483, Aug 17 2009, 17:02:12) [MSC v.1500 32 bit (Intel)] on
win32
Type "copyright", "credits" or "license()" for more information.

>>> sam_age = 18
>>> jim_age = 12
>>> if jim_age > sam_age:
...     print("sam is older")
... else:
...     print("jim is older")

SyntaxError: invalid syntax (<pyshell#4>, line 3)
>>> |
```



Motivation

- ▶ Provide community with a **central repository** of tests for common HPC apps
- ▶ Ability to automate test creation and execution without any user intervention
- ▶ A framework to automate testing for complete Software Stack in HPC

What is buildtest

- ▶ buildtest is a testing framework for Software Stack and System Packages
- ▶ buildtest makes use configuration files (YAML) for writing tests
- ▶ The framework is implemented in Python
- ▶ buildtest is **NOT** meant to support **interactive testing**

What can you do with buildtest

- Create tests for binaries, scripting languages and compilation
- generate system package tests
- List unique software all versions of each software package
- Search for configuration files and test scripts
- Support for Logging
- Support for TAB completion
- Retrieve easyconfigs from module tree
- Show difference between modules trees

What can you do with buildtest

- ▶ Create tests for scripting languages (R, Python, Perl, Ruby, TCL)
- ▶ Run test through interactive menu
- ▶ Scan tests that can be built using buildtest
- ▶ Support for different shells (csh, bash, sh)
- ▶ Support for job script creation for each test
- ▶ Auto-submit jobs to scheduler

What can you do with buildtest

- ▶ Run all tests through ctest utility
- ▶ Generate YAML configuration from buildtest for system packages
- ▶ Parameterize tests for MPI and OpenMP
- ▶ Specify scheduler configuration in YAML config
- ▶ Conduct **module load** test for all module files

Demo

Test Breakdown in buildtest repos

Tests Type	Count
EasyBuild Packages	30
System Packages	36
MPI Tests	21
Python Package Test	30
R Package Test	108
Perl Package Test	4
Ruby Package Test	2
TCL Test	1

How is buildtest used in Pfizer

- ▶ We support 2 cluster (Durham, Andover)
- ▶ Durham: 10 module trees, Andover: 7 module trees
- ▶ We use Jenkins to test each module tree
- ▶ Retrieve easyconfigs list from eb-2018-test tree to build for eb-2018-prod tree
- ▶ Use buildtest to view difference between architecture module trees to ensure software is present for each architecture

Test Breakdown for Durham Cluster

Jenkins Job	Count
buildtest-Durham-eb-2018-IvyBridge-test	267
buildtest-Durham-eb-2018-Haswell-test	267
buildtest-Durham-eb-2018-Broadwell-test	267
buildtest-Durham-eb-2018-SkyLake-test	204
buildtest-Durham-eb-2018-IvyBridge-prod	250
buildtest-Durham-eb-2018-Haswell-prod	250
buildtest-Durham-eb-2018-Broadwell-prod	267
buildtest-Durham-eb-2018-SkyLake-prod	250
buildtest-Durham-eb-2017	2036
buildtest-Durham-legacystack	5486
buildtest-Durham-system-package-testing	354

Test Breakdown for Andover Cluster

Jenkins Job	Count
buildtest-Andover-eb-2018-SandyBridge-prod	75
buildtest-Andover-eb-2018-IvyBridge-prod	97
buildtest-Andover-eb-2018-Haswell-prod	97
buildtest-Andover-eb-2018-Broadwell-prod	75
buildtest-Andover-eb-2017-IvyBridge	561
buildtest-Andover-legacystack	5474

Why use buildtest?

- ▶ Software Stack refresh
- ▶ OS upgrade
- ▶ Diagnose software issues before pushing to production
- ▶ Procure new system and build and test software stack
- ▶ Continuous Testing for reproducible software stack
- ▶ Validated Container – Software Stack Testing inside Container

My competition

- ▶ Automatic Testing of Installed Software (ATIS)
- ▶ Focus on MPI testing
- ▶ Make use for CTEST framework with CDASH to report tests in dashboard
- ▶ <https://github.com/besserox/ATIS>
- ▶ No activity on this project since 2014

https://archive.fosdem.org/2014/schedule/event/hpc_devroom_automatic_testing/

buildtest configuration

```
[siddis14@amrndh11157 buildtest-framework]$ buildtest --show
```

buildtest configuration summary

(C): Configuration File, (E): Environment Variable

BUILDTEST_ROOT	(E): /home/siddis14/github/buildtest-framework
BUILDTEST_CONFIGS_REPO	(C) = /lustre/workspace/home/siddis14/buildtest-configs
BUILDTEST_IGNORE_EASYBUILD	(C) = False
BUILDTEST_JOB_TEMPLATE	(C) = template/job.slurm
BUILDTEST_LOGDIR	(E) = /home/siddis14/github/buildtest-framework/logs
BUILDTEST_MODULE_NAMING_SCHEME	(C) = HMNS
BUILDTEST_MODULE_ROOT	(C) = /nfs/grid/software/RHEL6/general:/nfs/grid/software/RHEL6/chemistry:/nfs/grid/sc
BUILDTEST_PERL_REPO	(C) = /lustre/workspace/home/siddis14/Perl-buildtest-config
BUILDTEST_PYTHON_REPO	(C) = /lustre/workspace/home/siddis14/Python-buildtest-config
BUILDTEST_RUBY_REPO	(C) = /lustre/workspace/home/siddis14/Ruby-buildtest-config
BUILDTEST_R_REPO	(C) = /lustre/workspace/home/siddis14/R-buildtest-config
BUILDTEST_SHELL	(C) = sh
BUILDTEST_TCL_REPO	(C) = /lustre/workspace/home/siddis14/Tcl-buildtest-config
BUILDTEST_TESTDIR	(C) = /tmp/buildtest-tests

http://buildtestdocs.readthedocs.io/en/latest>Show_Configuration.html

Show diff between module trees

```
[siddis14@amrndhl1157 buildtest-framework]$ buildtest --diff-trees /nfs/grid/software/easybuild/2018/Broadwell/redhat/7.3/all,/clust/app/ea  
Comparing Module Trees for differences in module files
```

Module Tree 1: /nfs/grid/software/easybuild/2018/Broadwell/redhat/7.3/all

Module Tree 2: /clust/app/easybuild/2018/SkyLake/redhat/7.3/modules/all

ID	Module	Module Tree 1	Module Tree 2
1	OpenMM/7.1.1-intel-2018a-Python-2.7.14	FOUND	NOT FOUND
2	BamTools/2.5.1-intel-2018a	FOUND	NOT FOUND
3	SAMtools/1.6-intel-2018a	FOUND	NOT FOUND
4	GLPK/4.61-intel-2018a	FOUND	NOT FOUND
5	BEDTools/2.27.1-intel-2018a	FOUND	NOT FOUND
6	Ruby/2.5.0-intel-2018a	FOUND	NOT FOUND
7	git/2.16.1-intel-2018a	FOUND	NOT FOUND
8	JAGS/4.3.0-intel-2018a	FOUND	NOT FOUND
9	netCDF-Fortran/4.4.4-intel-2018a	FOUND	NOT FOUND
10	BWA/0.7.17-intel-2018a	FOUND	NOT FOUND

http://buildtestdocs.readthedocs.io/en/latest/Find_Operations.html#difference-between-module-trees-diff-trees

Retrieve easyconfigs from module tree

```
[siddis14@amrndhl1157 buildtest-framework]$ buildtest -ecmt
```

```
List of easyconfigs found in MODULETREES: ['/nfs/grid/software/RHEL6/general', '/nfs/grid/software/RHEL6/chemistry', '/nfs/grid/software/RH
```

ID	easyconfig path
1	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/SQLite/3.21.0-GCCcore-6.4.0/easybuild/SQLite-3.21.0-GCCcore-6.4.0.eb
2	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/SQLite/3.20.1-GCCcore-6.4.0/easybuild/SQLite-3.20.1-GCCcore-6.4.0.eb
3	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/expat/2.2.4-GCCcore-6.4.0/easybuild/expat-2.2.4-GCCcore-6.4.0.eb
4	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/Tcl/8.6.7-GCCcore-6.4.0/easybuild/Tcl-8.6.7-GCCcore-6.4.0.eb
5	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/Tcl/8.6.8-GCCcore-6.4.0/easybuild/Tcl-8.6.8-GCCcore-6.4.0.eb
6	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/bzip2/1.0.6-GCCcore-6.4.0/easybuild/bzip2-1.0.6-GCCcore-6.4.0.eb
7	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/icc/2018.1.163-GCC-6.4.0-2.28/easybuild/icc-2018.1.163-GCC-6.4.0-2.28.eb
8	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/GDAL/2.2.2-intel-2018a-Python-2.7.14/easybuild/GDAL-2.2.2-intel-2018a-Pyt
9	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/GCC/6.4.0-2.28/easybuild/GCC-6.4.0-2.28.eb
10	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/pkg-config/0.29.2-GCCcore-6.4.0/easybuild/pkg-config-0.29.2-GCCcore-6.4.0.eb
11	/nfs/grid/software/easybuild/IvyBridge/redhat/7.3/software/Tk/8.6.7-intel-2018a/easybuild/Tk-8.6.7-intel-2018a.eb

http://buildtestdocs.readthedocs.io/en/latest/Find_Operations.html#list-easyconfigs-from-module-trees-buildtest-ecmt

Test module load for all modules in module-tree

```
[siddis14@amrndh11228 buildtest-framework]$ buildtest --module-load-test
STATUS: PASSED - Testing module: VNL-ATK/2016.4
STATUS: PASSED - Testing module: anaconda2/4.2.0-chemistry
STATUS: PASSED - Testing module: anaconda3/4.2.0-chemistry
STATUS: PASSED - Testing module: bcl2fastq2/v2.17.1.14
STATUS: PASSED - Testing module: ccp4/7.0
STATUS: PASSED - Testing module: ccp4/7.0-nightly
STATUS: PASSED - Testing module: cellranger/1.2.1
STATUS: PASSED - Testing module: gaussian/g16.a03.avx
STATUS: PASSED - Testing module: gaussian/g16.a03.avx2
STATUS: PASSED - Testing module: gaussian/g16.a03.legacy
STATUS: PASSED - Testing module: gaussian/g16.a03.sse4
STATUS: PASSED - Testing module: hmmer/3.1b2
STATUS: PASSED - Testing module: materialstudios/2018
STATUS: PASSED - Testing module: openeye/2017
STATUS: PASSED - Testing module: phenix/dev2666
STATUS: PASSED - Testing module: rosetta/3.7
STATUS: PASSED - Testing module: turbomole/7.11
STATUS: PASSED - Testing module: turbomole/7.12
STATUS: PASSED - Testing module: xds/20161205
```

http://buildtestdocs.readthedocs.io/en/latest/module_load_test.html

Binary Test Example

```
binaries:
  - c++ --version
  - cpp --version
  - g++ --version
  - gcc --version
  - gcc-ar --version
  - gcc-nm --version
  - gcc-ranlib --version
  - gcov --version
  - gcov-tool --version
  - gfortran --version
```

```
#!/bin/sh
module purge
module load GCC/5.4.0-2.27
gcc --version
```

http://buildtestdocs.readthedocs.io/en/latest/Writing_Test_In_YAML.html

Passing Arguments

```
name: arg
source: arg.py
args: hello world
```

```
#!/bin/sh
module purge
module load foss/.2016.03
module load Python/2.7.12
python /hpc/hpcswadm/buildtest/buildtest-configs/ebapps/Python/code/arg.py hello world
```

http://buildtestdocs.readthedocs.io/en/latest/Writing_Test_In_YAML.html

Scheduler Example

```
name: mpi_mm.f
source: mpi_mm.f
mpi: enabled
buildopts: -O2
nproc: 4
scheduler: "SLURM"
jobslots: 4
```

```
buildtest -s OpenMPI/2.0.0 -t GCC/5.4.0-2.27 --testset MPI --enable-job
```

```
#!/bin/sh
#SBATCH -N 4
module purge
module load GCC/5.4.0-2.27
module load OpenMPI/2.0.0
mpifort -o mpi_mm.f.exe /lustre/workspace/home/siddis14/buildtest-framework/buildtest-configs/mpi/code/mpi_mm.f -O2
mpirun -np 4 ./mpi_mm.f.exe
```

http://buildtestdocs.readthedocs.io/en/latest/Jobscript_yaml_configuration.html

Parameterize MPI Tests

```
name: hello_arg.c
source: hello_arg.c
mpi: enabled
args:
    - hi
    - how
    - are
    - you
procrange: 2,20,4
```

```
[siddis14@amrndhl1157 buildtest-framework]$ ls -l /hpc/grid/hpcws/hpcengineers/siddis14/buildtest-framework/testing/ebapp/OpenMPI/2.0.0/GCC/5.4.0-2.27/hello_arg.c_nproc_*
-rw-rw-r-- 1 siddis14 hpceng 246 Nov 27 18:09 /hpc/grid/hpcws/hpcengineers/siddis14/buildtest-framework/testing/ebapp/OpenMPI/2.0.0/GCC/5.4.0-2.27/hello_arg.c_nproc_10.sh
-rw-rw-r-- 1 siddis14 hpceng 246 Nov 27 18:09 /hpc/grid/hpcws/hpcengineers/siddis14/buildtest-framework/testing/ebapp/OpenMPI/2.0.0/GCC/5.4.0-2.27/hello_arg.c_nproc_14.sh
-rw-rw-r-- 1 siddis14 hpceng 246 Nov 27 18:09 /hpc/grid/hpcws/hpcengineers/siddis14/buildtest-framework/testing/ebapp/OpenMPI/2.0.0/GCC/5.4.0-2.27/hello_arg.c_nproc_18.sh
-rw-rw-r-- 1 siddis14 hpceng 244 Nov 27 18:09 /hpc/grid/hpcws/hpcengineers/siddis14/buildtest-framework/testing/ebapp/OpenMPI/2.0.0/GCC/5.4.0-2.27/hello_arg.c_nproc_2.sh
-rw-rw-r-- 1 siddis14 hpceng 245 Nov 27 18:09 /hpc/grid/hpcws/hpcengineers/siddis14/buildtest-framework/testing/ebapp/OpenMPI/2.0.0/GCC/5.4.0-2.27/hello_arg.c_nproc_6.sh
```

```
#!/bin/sh
module purge
module load GCC/5.4.0-2.27
module load OpenMPI/2.0.0
mpicc -o hello_arg.c.exe /hpc/grid/hpcws/hpcengineers/siddis14/buildtest-framework/buildtest-configs/mpi/code/hello_arg.c
mpirun -np 2 ./hello_arg.c.exe hi how are you
```

http://buildtestdocs.readthedocs.io/en/latest/MPI_yaml.html#mpi-yaml-example

Resources

- ▶ Documentation: <http://buildtestdocs.readthedocs.io/en/latest/>
- ▶ GitHub: <https://github.com/HPC-buildtest>
- ▶ Want a new feature or bug with buildtest-framework please submit an [issue](#)
- ▶ Join the slack channel <https://hpcbuildtest.slack.com/>
- ▶ Recording from [HPCKP-17](#)

Future Work

- ▶ Custom Exit Status Code
- ▶ Rename option --testset
- ▶ Add option --rebuild
- ▶ Add option --show-keys to display description of yaml keys
- ▶ Support for testing conda environments
- ▶ Package buildtest as pypi package

Conclusion

- ▶ Automate and share tests with HPC community.
- ▶ Don't waste time writing manual test scripts for site-specific configuration!
- ▶ Need a community effort to improve the framework and add more tests