CSCS
Centro Svizzero di Calcolo Scientifico
Swiss National Supercomputing Centre

ETH zürich

ReFrame: A regression framework for checking the health of large HPC systems

CUG 2017 conference, Redmond, WA, USA

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May 11, 2017

Outline

- Regression testing in HPC
- What is ReFrame?
- Writing a test in ReFrame
- CSCS use case

Regression testing of HPC systems

Why is it so important?

- Ensures quality of service
- Reduces downtime
- Early detection of problems

Regression testing of HPC systems

But it's a painful story

- In-house custom solutions per center
- Non portable monolithic regression tests
  - Tightly coupled to the system configuration and programming env.
- Large maintenance overhead
  - Replicated code of the system interaction details
  - Test's logic is lost in unrelated lower level details

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No one wants to implement a new regression test!

What is ReFrame?

A new regression framework that

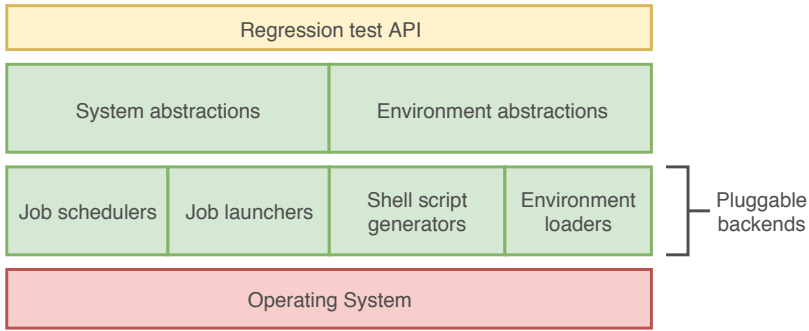
- allows writing portable HPC regression tests in Python,
- abstracts away the system interaction details,
- lets users focus solely on the logic of their test.

https://github.com/eth-cscs/reframe

Design goals

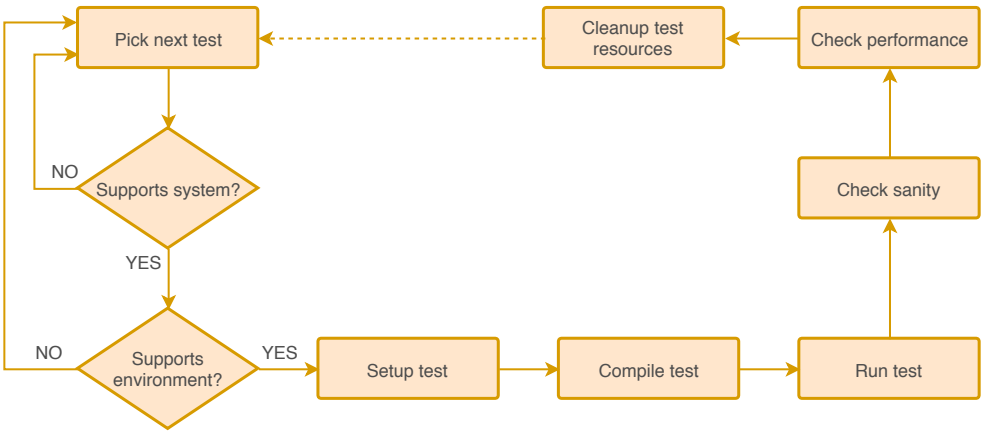
- *Productivity*
- *Portability*
- *Ease of use*
- *Robustness*

ReFrame's architecture



The regression test pipeline

A series of well defined phases that each regression test goes through



Writing regression tests in ReFrame

A “Hello, World!” example

```
import os
from reframe.core.pipeline import RegressionTest

class HelloWorldTest(RegressionTest):
    def __init__(self, **kwargs):
        super().__init__('hello_world', os.path.dirname(__file__), **kwargs)
        self.descr = 'Hello World C Test'
        self.sourcepath = 'hello.c'
        self.valid_systems = [ 'daint:gpu', 'daint:mc', 'daint:login' ]
        self.valid_prog_environs = [ 'PrgEnv-cray', 'PrgEnv-gnu' ]
        self.sanity_patterns = { '-': {'Hello, World\!': []} }

def _get_checks(**kwargs):
    return [ HelloWorldTest(**kwargs) ]
```

Writing regression tests in ReFrame

A “Hello, World!” example

A regression test needs not to care about

- how access to system partitions is gained,
- how programming environments are switched,
- how its environment is set up,
- how a sanity/performance pattern is looked up in its output,
- how a job script is generated and submitted and if it’s needed at all.

Writing regression tests in ReFrame

Specifying the test's environment

```
def __init__(self, **kwargs):
    ...
    self.modules = [ 'cudatoolkit', 'cray-libsci_acc' ]
    self.variables = {
        'CRAY_CUDA_MPS' : '1',
        'OMP_NUM_THREADS' : '16'
    }
```

- Modules will be loaded and environment variables will be set during the test's setup phase
- Corresponding instructions will be emitted in the generated run script
  - Possible module conflicts are handled automatically

Writing regression tests in ReFrame

Differentiating per system

- Different configurations to be tested, workarounds etc.

Writing regression tests in ReFrame

Differentiating per system

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```
def __init__(self, **kwargs):
    ...
    if self.current_system.name == 'dom':
        self.num_tasks = 72
        # workaround for Dom due to bug #XXX
        self.modules += [ 'foo' ]
    else:
        self.num_tasks = 192
```

Differentiation per system partition must be done inside the `setup()` method

Writing regression tests in ReFrame

Customizing compilation – Example: OpenMP compilation flags

```
def __init__(self, **kwargs):
    ...
    # user-defined member variable
    self.prgenv_flags = {
        'PrgEnv-cray'  : '-homp',
        'PrgEnv-gnu'   : '-fopenmp',
        'PrgEnv-intel' : '-openmp',
        'PrgEnv-pgi'   : '-mp'
    }

def compile(self):
    flag = self.prgenv_flags[self.current_environ.name]
    self.current_environ.cflags = flag
    super().compile()
```

– *Also support for running pre- and post-compilation commands*

Writing regression tests in ReFrame

Sanity and performance checking

- Regex pattern matching
- Associate callback actions to patterns matched
- Automatic reference value resolution for performance tests
- Stateful parsing support
  - Support for common aggregate operations (min, max, sum, average)
- Search for patterns in multiple files

Writing regression tests in ReFrame

Sanity and performance checking

- Simple `grep`-like matching:

```
def __init__(self, **kwargs):
    ...
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```

Writing regression tests in ReFrame

Sanity and performance checking

- Simple `grep`-like matching:

```
def __init__(self, **kwargs):
    ...
    self.sanity_patterns = { '-': {'Hello, World\!': []} }
```

- Pattern matching with associated action callbacks:

```
def __init__(self, **kwargs):
    ...
    self.sanity_patterns = {
        '-' : {
            'final result:\s+(?P<res>\d+\.?\d*)': [
                ('res', float, lambda value, **kwargs: \
                     standard_threshold(value, (1., -1e-5, 1e-5)))
            ],
        }
    }
```

Writing regression tests in ReFrame

Sanity and performance checking

```
def __init__(self, **kwargs):
    ...
    self.perf_patterns = {
        '-' : {
            'long_pattern (?P<days_ns>\S+) days/ns' : [
                ('days_ns', float, standard_threshold)
            ]
        }
    }
    self.reference = {
        'daint:gpu' : { 'days_ns' : (0.71, None, 0.10) },
        'daint:mc'  : { 'days_ns' : (0.90, None, 0.10) } }
```

Writing regression tests in ReFrame

Sanity and performance checking

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def __init__(self, **kwargs):
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```

For each matched tag `standard_threshold(float(val), ref)` will be called.

- `val` is the value of the matched tag
- `ref` is looked up in `self.reference`

Writing regression tests in ReFrame

Sanity and performance checking – Stateful parsing

“The average performance of the first 100 steps must be within 10% of the reference value for this system.”

Writing regression tests in ReFrame

Sanity and performance checking – Stateful parsing

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- ReFrame's action callbacks come in very handy in such situations
  - Create an object holding the desired state and update it with every match
- ReFrame supports also eof callback actions, allowing to take a decision after processing the whole output

Writing regression tests in ReFrame

Sanity and performance checking – Stateful parsing

"The average performance of the first 100 steps must be within 10% of the reference value for this system."

- ReFrame's action callbacks come in very handy in such situations
  - Create an object holding the desired state and update it with every match
- ReFrame supports also eof callback actions, allowing to take a decision after processing the whole output
- Use ReFrame's provided parsers that cover the most common cases

Writing regression tests in ReFrame

Organizing the regression tests

```
mychecks/
   compile/
      helloworld/
          helloworld.py
          src/          # <- source files are resolved relative to this directory
              hello.c
   runonly/
      app/
          src/          # <- test resources files can be put simply here
              input.txt
          apptest.py
```

- Default check path in `<reframe-install-prefix>/checks/`
- Resources directory can also be customized per test

ReFrame's front-end

Configuring for a new site

- Systems
  - Hostname identification patterns
  - ReFrame's stage and output directories
- System logical partitions
  - Job scheduler
  - Environment to always load on that partition
  - Scheduler options enabling access to that partition
  - List of programming environments to test
- Programming environments
  - Modules
  - Environment variables
  - Compilers and default flags

ReFrame's front-end

Configuring for a new site – Piz Daint example

```
'systems' : {
    'daint' : {
        'hostnames' : [ 'daint', 'daint\d+' ],
        'partitions' : {
            'login' : {
                'scheduler' : 'local',
                'environs'  : [ 'PrgEnv-cray', 'PrgEnv-gnu',
                                'PrgEnv-intel', 'PrgEnv-pgi' ],
                'descr'     : 'Login nodes'
            },
            'gpu' : {
                'scheduler' : 'nativeslurm',
                'modules'   : [ 'daint-gpu' ],
                'access'    : [ '--constraint=gpu' ],
                'environs'  : [ 'PrgEnv-cray', 'PrgEnv-gnu',
                                'PrgEnv-intel', 'PrgEnv-pgi' ],
                'descr'     : 'Hybrid nodes (Haswell/P100)',
            }
        }}}
```

ReFrame's front-end

Configuring for a new site – Piz Daint example (cont'd)

```
'environments' : {
    '*' : {
        'PrgEnv-gnu' : {
            'type' : 'ProgEnvironment',
            'modules' : [ 'PrgEnv-gnu' ],
        },
        ...
    }
    'kesch' : {      # PrgEnv-gnu redefinition for Piz Kesch
        'PrgEnv-gnu' : {
            'type' : 'ProgEnvironment',
            'modules' : [ 'PrgEnv-gnu' ],
            'cc'      : 'mpicc',
            'cxx'     : 'mpicxx',
            'ftn'     : 'mpif90',
        }
    }
}
```

ReFrame's front-end

Command-line interface

ReFrame goes through three phases when invoked:

- Discovery and loading of regression tests
- Selection/filtering of the loaded tests
  - By name, programming environment, tags
- Action on the final set of tests
  - Listing or execution

ReFrame's front-end

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In case of a test failure, test's files are left intact in its stage directory:

- User can inspect and try to manually reproduce the error

The CSCS use case

Sanity and performance checking of Piz Daint

- Production test suite
  - Wide variety of tests running daily overnight
  - Testing hybrid and multicore system partitions as well as login nodes
  - 157 tests run, 437 test cases in total
- Maintenance test suite
  - Run before and after each maintenance session
  - Slurm functionality, I/O of core filesystems, performance of critical apps
  - $\leq$ 30 min

The CSCS use case

Comparison with our old shell script based solution

Component	*Old framework*	*ReFrame*
Core	N/A	3660 loc
Front-end	1038 loc	958 loc
Regression tests	14635 loc	**2985 loc**

The CSCS use case

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Component	*Old framework*	*ReFrame*
Core	N/A	3660 loc
Front-end	1038 loc	958 loc
Regression tests	14635 loc	**2985 loc**
Avg. regression file size	179 loc	**93 loc**
Avg. regression test size	179 loc	**25 loc**

Almost 5× reduction of the total amount of regression test code!

Conclusions and future directions

ReFrame makes writing regression tests for HPC systems an easy task!

- Actively developed
- More teams inside CSCS have started to adopt it in their projects
- Publicly available at *https://github.com/eth-cscs/reframe*

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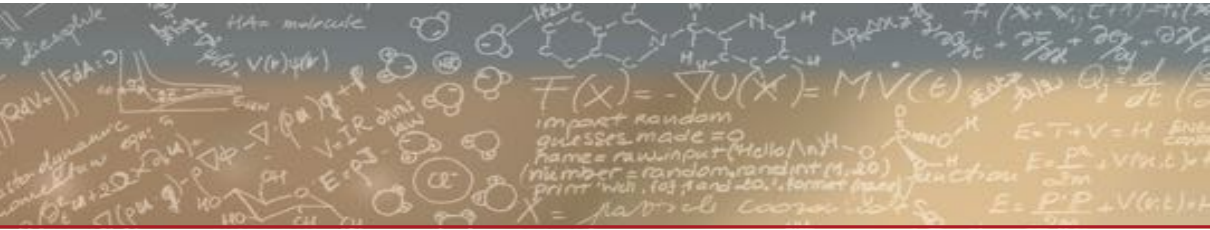
High-priority items from our backlog

- Proper logging
- Backend for the PBS scheduler
- Asynchronous execution of regression tests

Try it out, give us some feedback!



Thank you for your attention