Continuous Integration

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- **The requested citation the overall tutorial is: David E. Bernholdt, Anshu Dubey, Mark C. Miller, Katherine M. Riley, and James M. Willenbring, Software Productivity Track, in Argonne Training Program for Extreme Scale Computing (ATPESC), August 2020, online. DOI: 10.6084/m9.figshare.12719834**
- Individual modules may be cited as *Speaker, Module Title*, in Software Productivity Track…

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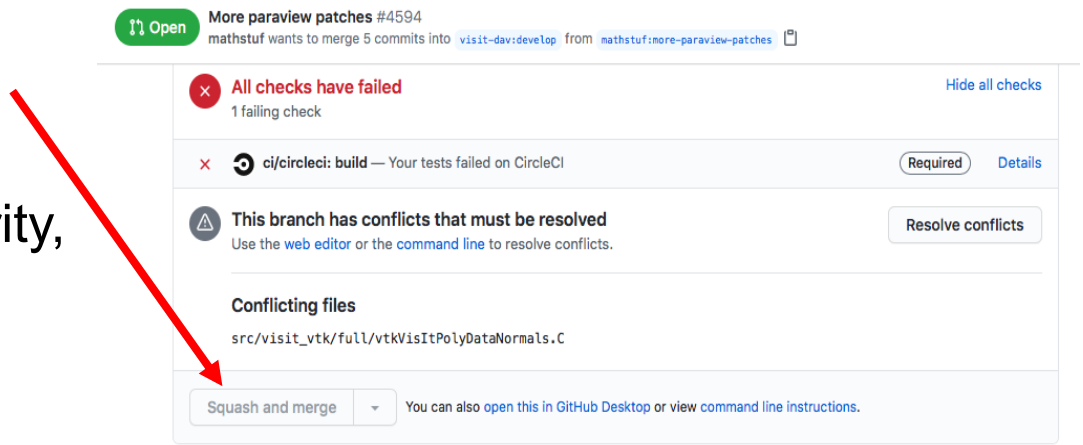
What is Continuous Integration (CI) *Testing*

- Testing
  - Focused, critical functionality (infrastructure), fast, independent, orthogonal, complete, …
  - Existing test suites often require re-design/refactoring for CI
- Integration
  - Changes across key branches merged & tested to ensure the “whole” still works
  - Develop, develop, develop, merge, merge, merge, test, test, test…NO!
  - Develop, merge, test, develop, merge, test, develop, merge, test…YES!
- Continuous
  - Changes tested every commit and/or pull-request (like auto-correct)
- CI generally implies a lot of automation

Automated Testing vs. Continuous Integration (CI) Testing

- ***Automated Testing***: Software that automatically performs tests and reliably detects and reports anomalous behaviors/outcomes.
  - Examples: Auto-test, CTest/CDash, nightly testing, `make check'
  - Potential issues: change attribution, timeliness of results, multiple branches of development

- ***Continuous Integration (CI)***: automated testing performed at high frequency and fine granularity aimed at *preventing* code changes from breaking key branches of development (e.g. *main*)
  - Example: Disabled/enabled "Merge Pull Request" button on GitHub
  - Potential issues: extreme automation, test granularity, coverage, 3rd-party services/resources



Examples…

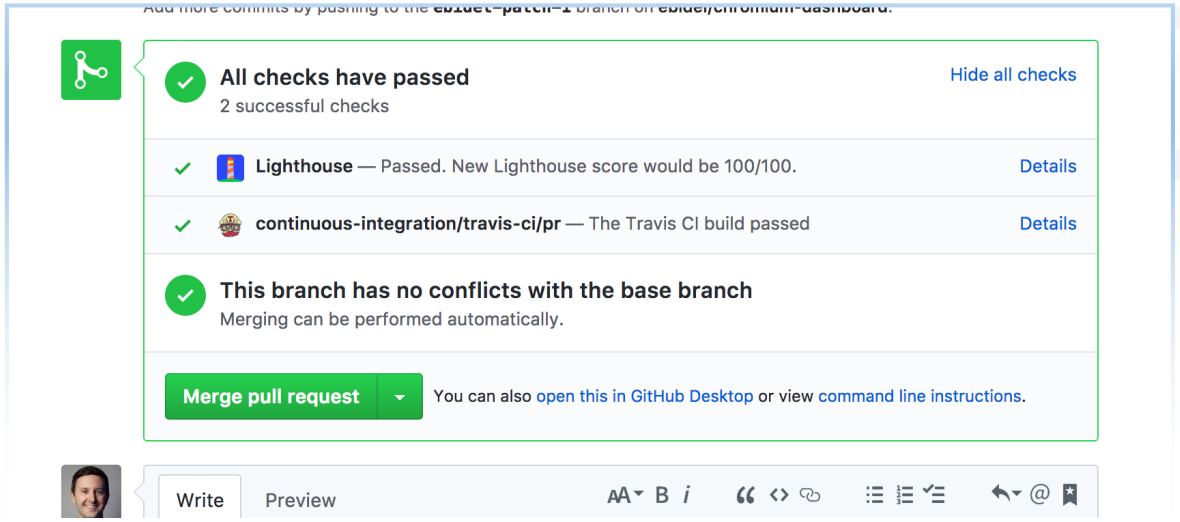
Automated Nightly Testing Dashboard
Lives "next to" your development work

Results of VisIt Regression Test (pascal,trunk,serial)

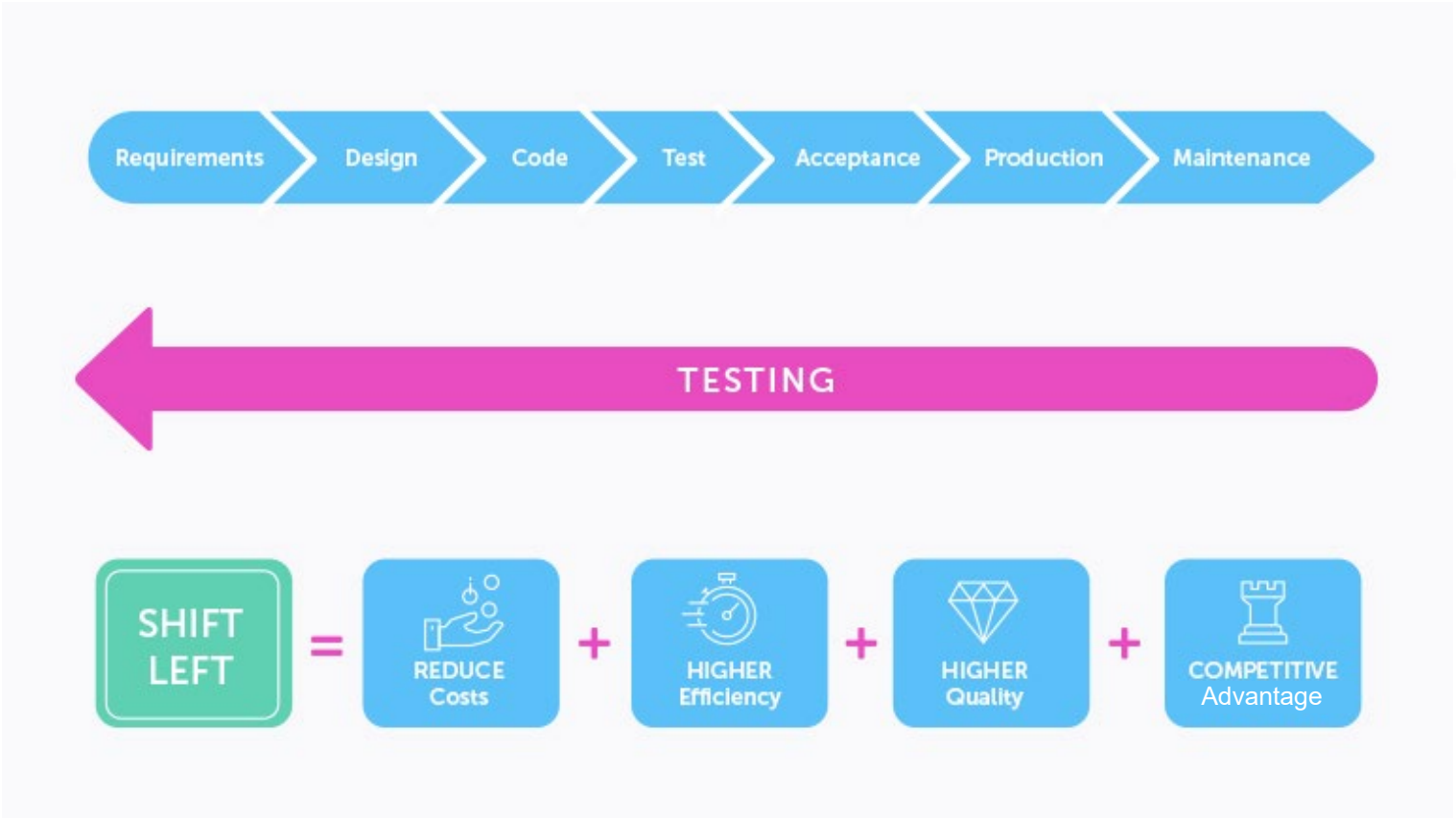
Test suite run started at 2020:07:09:22:49:46.
(Click on table header to sort)

Index	Category	Test File	Status	Runtime (sec)
243	rendering	ospray.py	Unacceptable	5.0
273	simulation	batch.py	Unacceptable	38.0
24	databases	chgcar.py	Succeeded With Skips	11.0
32	databases	exodus.py	Succeeded With Skips	14.0
66	databases	silo.py	Succeeded With Skips	50.0
67	databases	silo_altdriver.py	Succeeded With Skips	87.0
75	databases	xdmf.py	Succeeded With Skips	14.0
109	hybrid	merge_tree.py	Succeeded With Skips	11.0
136	meshtype	emptydomains.py	Succeeded With Skips	7.0
256	rendering	view.py	Succeeded With Skips	17.0
275	simulation	curve.py	Succeeded With Skips	8.0
281	simulation	life.py	Succeeded With Skips	8.0
296	simulation	zerocopy.py	Succeeded With Skips	32.0
0	databases	ANALYZE.py	Succeeded	10.0
1	databases	ANSYS.py	Succeeded	9.0
2	databases	CGNS.py	Succeeded	11.0
3	databases	Cale.py	Succeeded	6.0
4	databases	Chombo.py	Succeeded	7.0
5	databases	EnSight.py	Succeeded	9.0
6	databases	FITS.py	Succeeded	8.0
7	databases	Fluent.py	Succeeded	7.0
8	databases	GDAL.py	Succeeded	20.0
9	databases	NASTRAN.py	Succeeded	15.0

CI Testing
Lives embedded in your development work



CI Testing is one part of the “Shift Left” movement in DevOps



What can make CI Difficult

Common situations

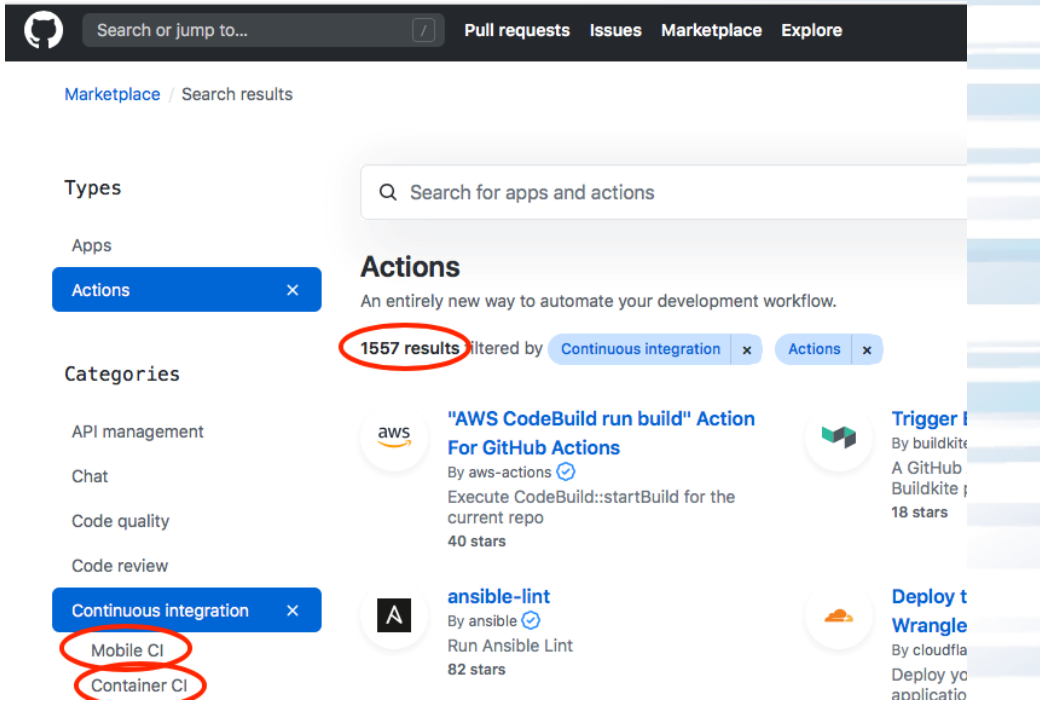
- Just getting started
  - Many technologies/choices; often in the ”cloud”
  - Solution: start small, simple, build up
- Developing suitable tests
  - Many project’s existing tests not suitable for CI
  - Solution: Simplify/refactor and/or sub-setting test suite
- Ensuring sufficient coverage
  - Some changes to code never get tested
  - Solution: tools to measure it, enforce always increasing

Advanced situations

- Defining failure for *many* configurations
  - Bit-for-bit (exact) match vs. fuzzy match
  - Solution: absolute/relative tolerances → AI/ML
- Numerous 3rd party libraries (TPLs)
  - Compiling takes too long
  - Solution: cache pre-built TPLs, containers
- Performance testing
  - Avoid time-, space-, scaling-performance degradation
  - Solution: Perf. instrumentation and *scheduled* testing

CI Resources (Where do jobs run?)

- Free Cloud Resources (many free on GitHub, BitBucket, GitLab, etc.)
  - Travis-CI, Circle-CI, AppVeyor, Azure Pipelines,…
  - All launch a VM (Linux variants, Windows and OSX)
    - Constrained in time/size, config. (e.g. GPU type/count)
    - Not always suitable for large, HPC projects due to need for longer than usual time to run



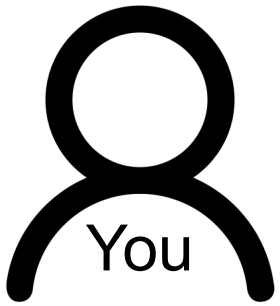
- Site-local Resources
  - Examples: Bamboo @ LLNL, Jenkins @ ANL, Travis+CDash @ NERSC, etc.
  - ECP Program: GitLab-CI @ ANL, LANL, LLNL, NERSC, ORNL, SNL

- Create your own by setting up resources/services

Examples…

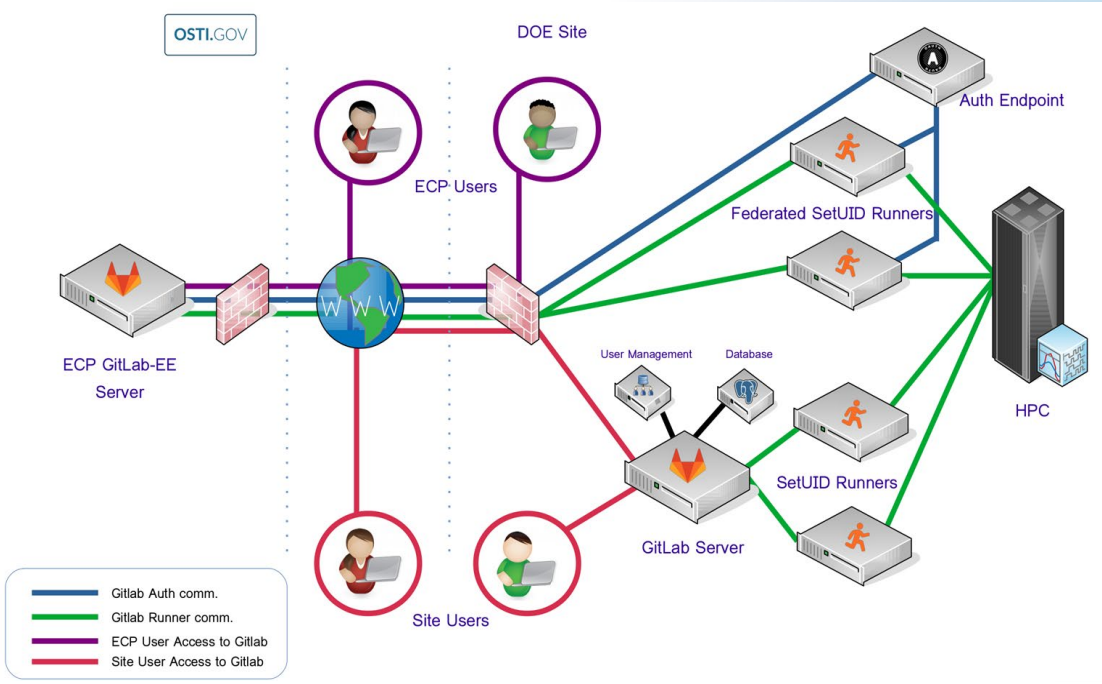
Your code repository

Your CI Resources



ECP CI Resources

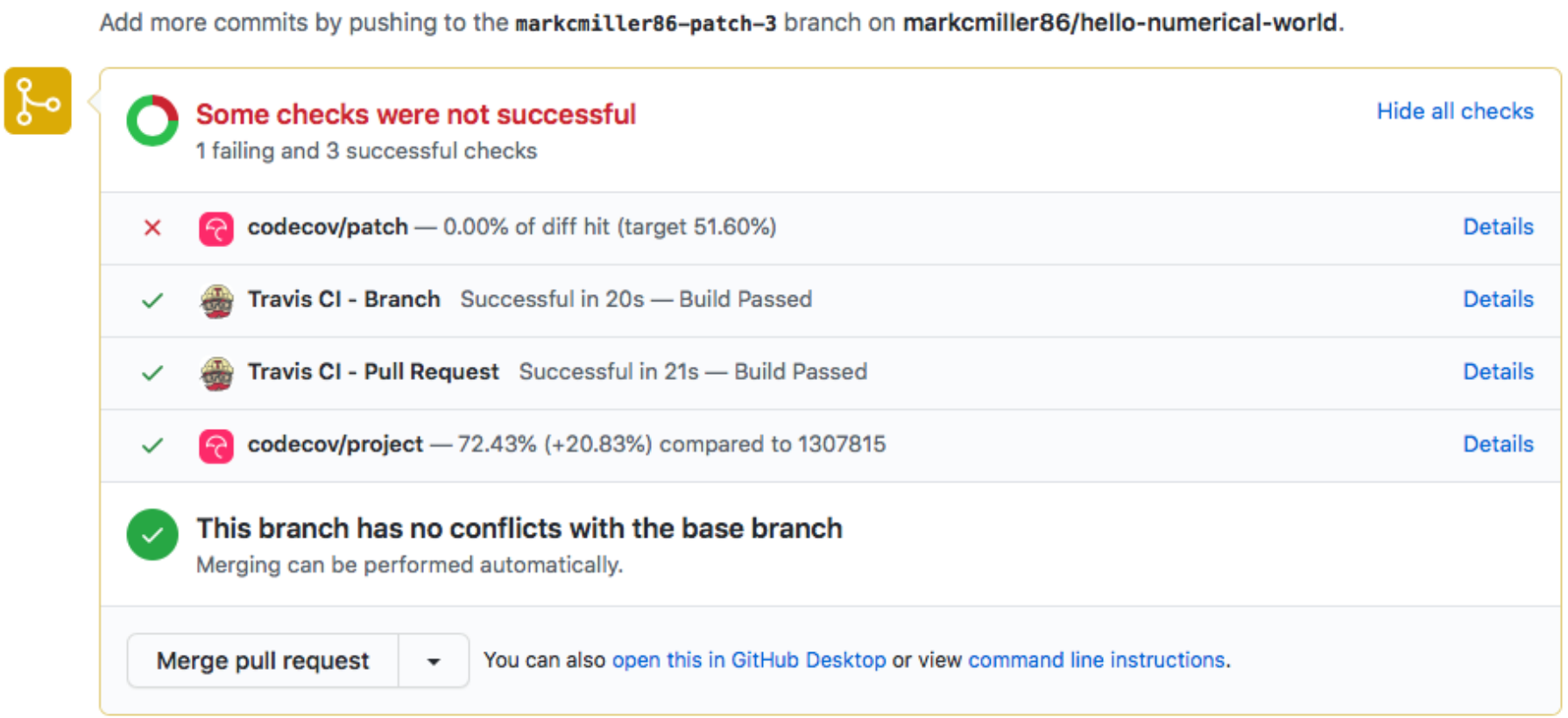
- ECP investing in GitLab for complex-wide CI
- Non-GitLab projects *mirror* into GitLab
- Complex-wide Federation via OSTI
  - Many hurdles still to overcome
  - Manual federation possible…but non-trivial
- Documentation and on-boarding help
  - https://ecp-ci.gitlab.io
  - email me, miller86@llnl.gov for on-boarding contacts



Getting started with CI

- What *configuration* is most important?
  - Examples: gcc, icc, xlc? MPI-2 or MPI-3? Python 2, 3 or 2 & 3?
- What *functionality* is most important?
  - Examples: vanilla numerical kernels? OpenMP kernels? GPU kernels? All of these?
- Good candidates…
  - A “hello world” example for your project
  - Once you’ve got the basics working, its easy to build up from there

https://github.com/betterscientificsoftware/hello-numerical-world



Getting started with CI:

Setting up CI

Service	Interface	
Travis	repo YAML file [& repo scripts]	/.travis.yml in root of repo
GitLab	Web page configurator + repo YAML file [& repo scripts]	/.gitlab-ci.yml in root of repo
Bamboo	Web page configurator + repo scripts	
. . .		

Example .travis.yml file (also doing coverage analysis)

```
1  language: c++
2
3  compiler:
4    - gcc
5
6  script:
7    - make CXXFLAGS=--coverage LDFLAGS="--coverage -lm" check_all
8
9  after_success:
10   - bash <(curl -s https://codecov.io/bash)
```

Getting started with CI:

Keywords specific to service being used

Specify environment

Commands to run

Example .travis.yml file
(also doing coverage analysis)

```
1  language: c++
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3  compiler:
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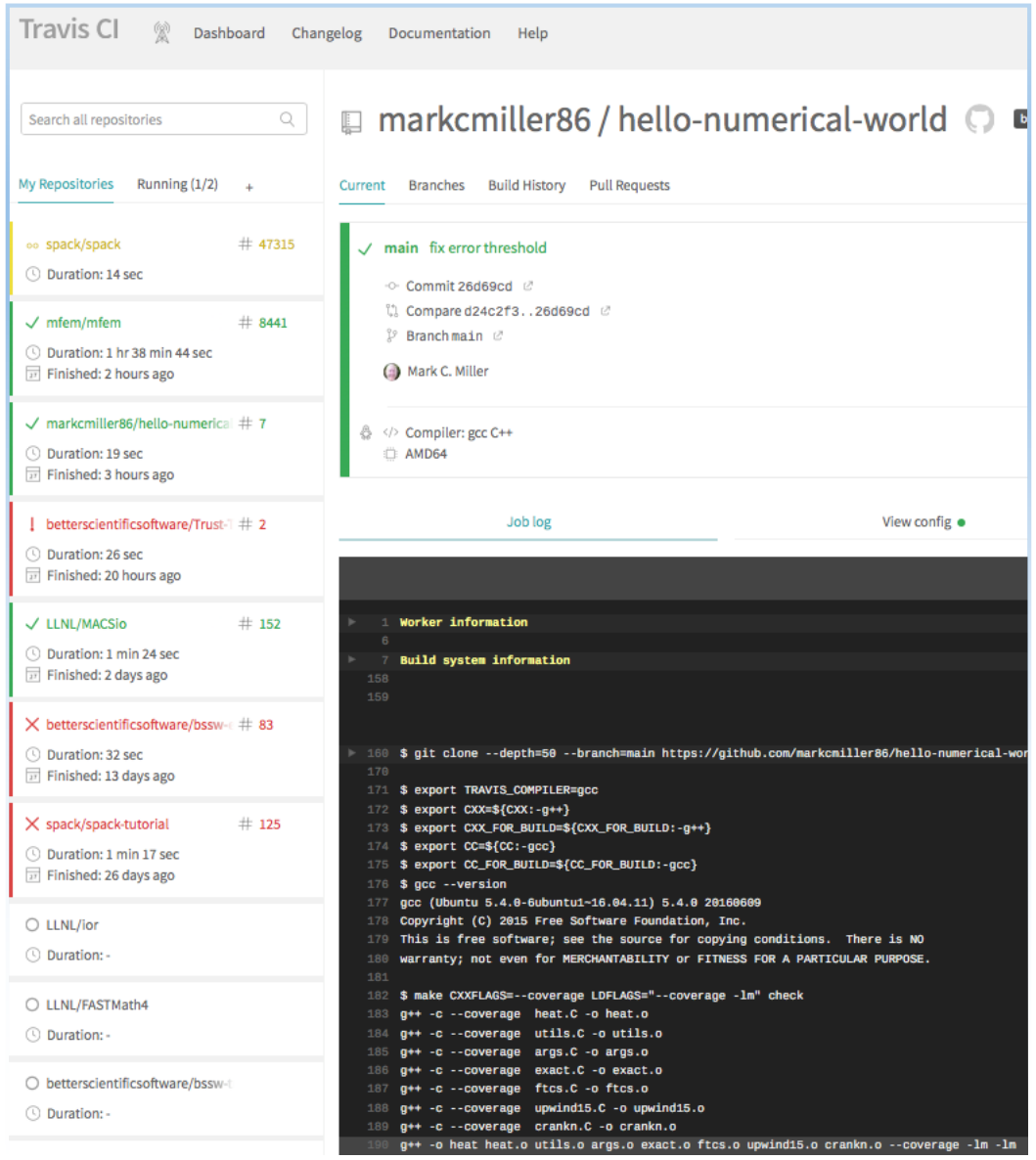
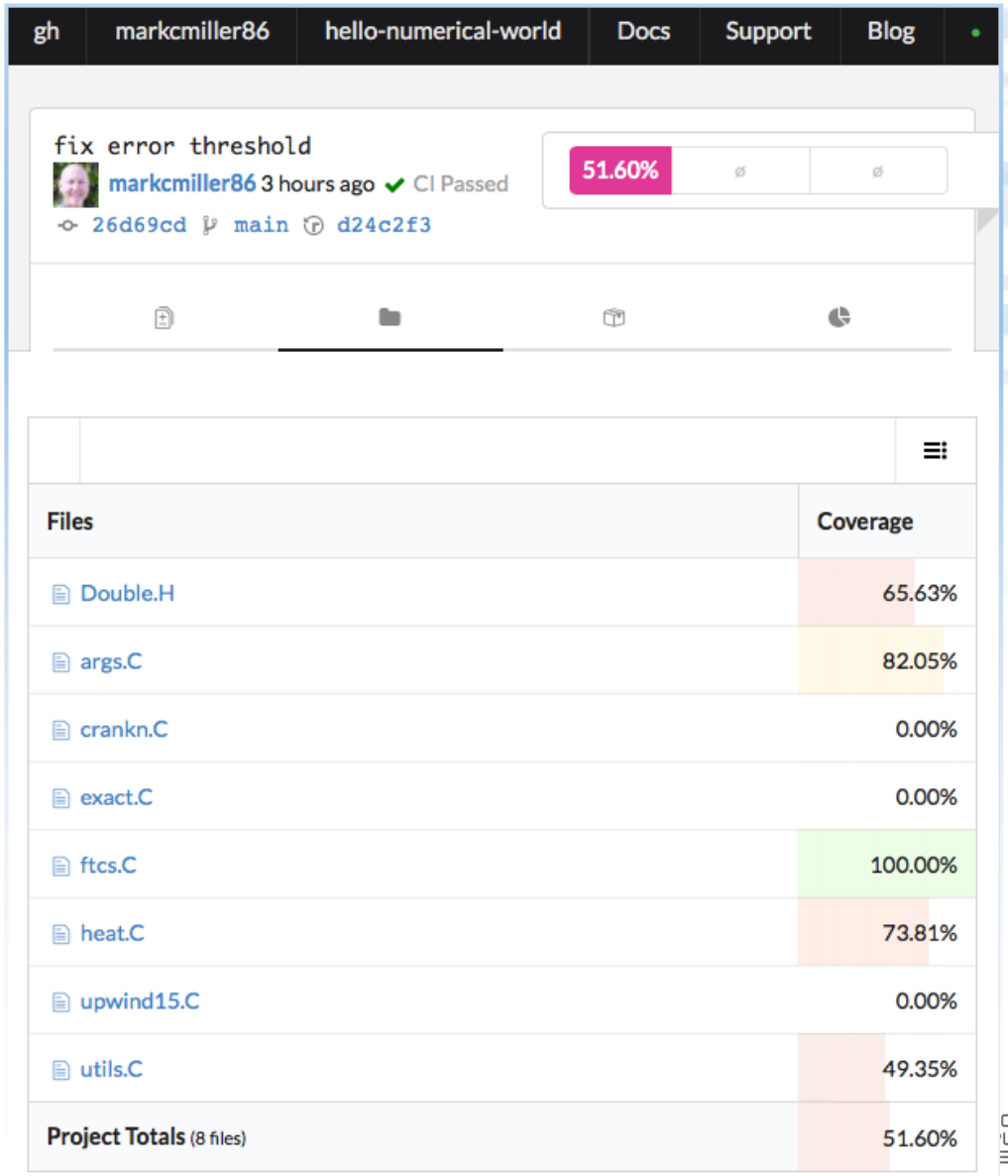
travis-ci.com



codecov.io



After Hours Hands-on Lesson – YouTube Video

- Follow QR code to GitHub repository
  - You can do this exercise entirely in your browser on GitHub
- Fork the repo
- Create .travis.yml using
- Submit Pull Request (PR)
- Increase coverage
  - Change ‘check’ to “check_all”
- Update the PR and observe coverage change
- Extra credit…fail PR if coverage drops
  - Hint: read codecov.io docs