



# Continuous Integration



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Better Scientific Software tutorial @ ISC 2022

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- **The requested citation the overall tutorial is: Anshu Dubey and Gregory R. Watson, Better Scientific Software Tutorial, in ISC High Performance, 2022, Hamburg Germany. DOI: 10.6084/m9.figshare.19781752**
- Individual modules may be cited as *Speaker, Module Title*, in Better Scientific Software tutorial, ISC, 2022 ...

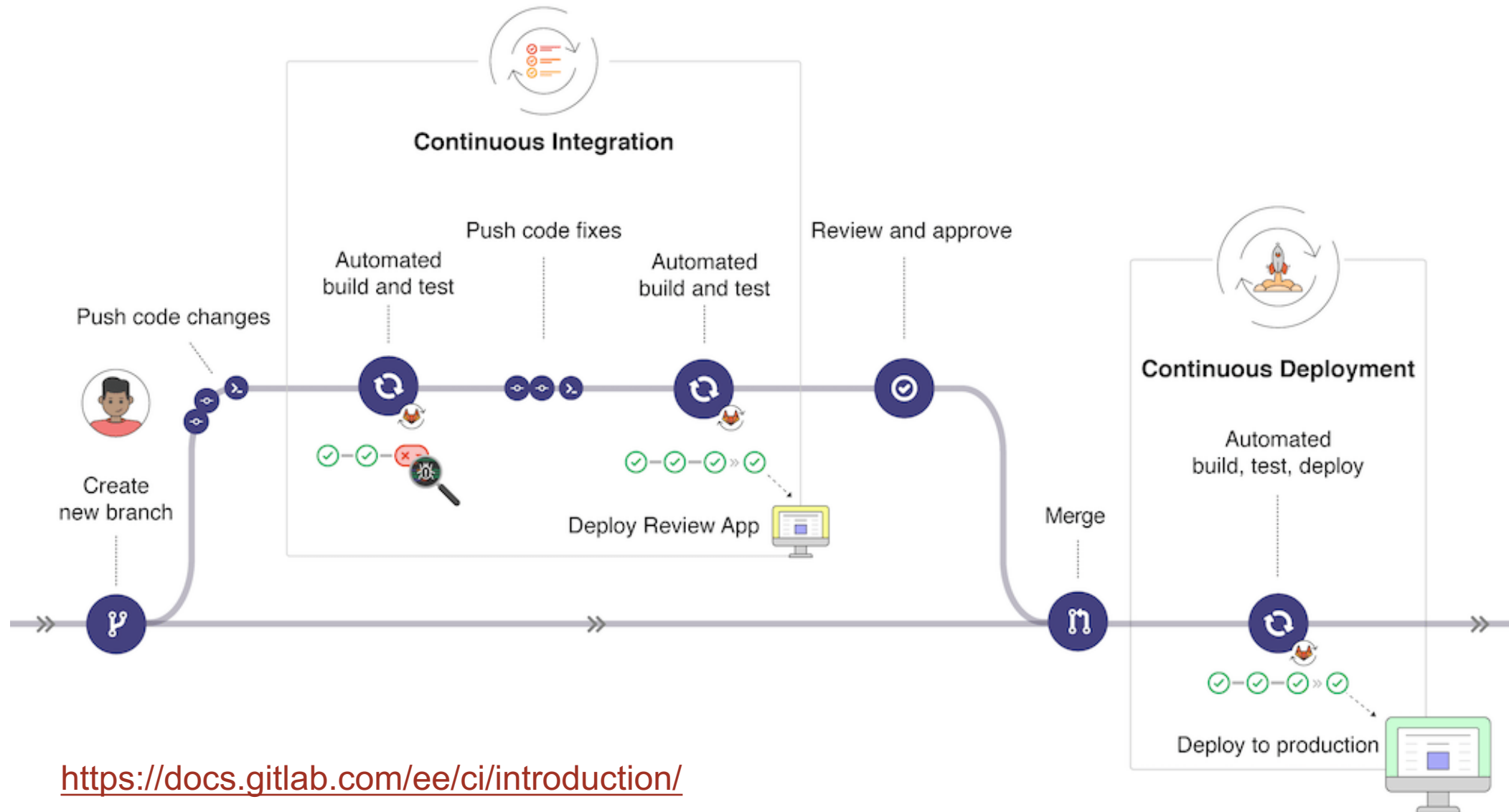


## Acknowledgements

- This work was supported by the U.S. Department of Energy Office of Science, Office of Advanced Scientific Computing Research (ASCR), and by the Exascale Computing Project (17-SC-20-SC), a collaborative effort of the U.S. Department of Energy Office of Science and the National Nuclear Security Administration.
- This work was performed in part at the Argonne National Laboratory, which is managed by UChicago Argonne, LLC for the U.S. Department of Energy under Contract No. DE-AC02-06CH11357.
- This work was performed in part at the Oak Ridge National Laboratory, which is managed by UT-Battelle, LLC for the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.
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- This work was performed in part at the Los Alamos National Laboratory, which is managed by Triad National Security, LLC for the U.S. Department of Energy under Contract No. 89233218CNA000001
- This work was performed in part at Sandia National Laboratories. Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.



# What is Continuous Integration (CI)



<https://docs.gitlab.com/ee/ci/introduction/>

# CI Components

- 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
    - Integration can take place at multiple levels
      - Individual project
      - Spack
      - E4S
  - Develop, develop, develop, merge, merge, merge, test, test, test...NO!
  - Develop, test, merge, develop, test, merge, develop, test, merge...YES!
- Continuous
  - Changes tested every commit and/or pull-request (like auto-correct)
- CI generally implies a lot of automation

# Test Driven Development vs. Automated Testing vs. CI

- ***Test Driven Development:*** A development methodology where functional test are written before the code
  - Works well with CI as tests are written and committed and are automatically run (failing)
  - Code that implements the functionality being tested retriggers the tests automatically
- ***Automated Testing:*** Software that automatically performs tests on a regular basis and reliably detects and reports anomalous behaviors/outcomes.
  - Examples: Auto-test, CTest/CDash, nightly testing, etc.
  - May live “next to” your development workflow
  - 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)
  - Lives “within” your development workflow
  - Potential issues: extreme automation, test granularity, coverage, 3<sup>rd</sup>-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	MASTRA.py	Succeeded	15.0


CI Testing  
Lives embedded in your development work


Add more commits by pushing to the `ebinet-patch-1` branch on `ebinet/chromium-dashboard`.



✓ All checks have passed Hide all checks

2 successful checks


✓  **Lighthouse** — Passed. New Lighthouse score would be 100/100. Details

✓  **continuous-integration/travis-ci/pr** — The Travis CI build passed Details

✓ **This branch has no conflicts with the base branch**  
Merging can be performed automatically.

Merge pull request

You can also [open this in GitHub Desktop](#) or view [command line instructions](#).



Write

Preview

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# 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
  - CI testing is a balance of thoroughness and responsiveness
  - Solution: Simplify/refactor and/or sub-setting test suite
- Ensuring sufficient coverage
  - Some changes to code never get tested – CI can provide a false sense of security
  - Solution: tools to measure it, enforce always increasing

## Advanced situations

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



# CI Resources (Where do jobs run?)

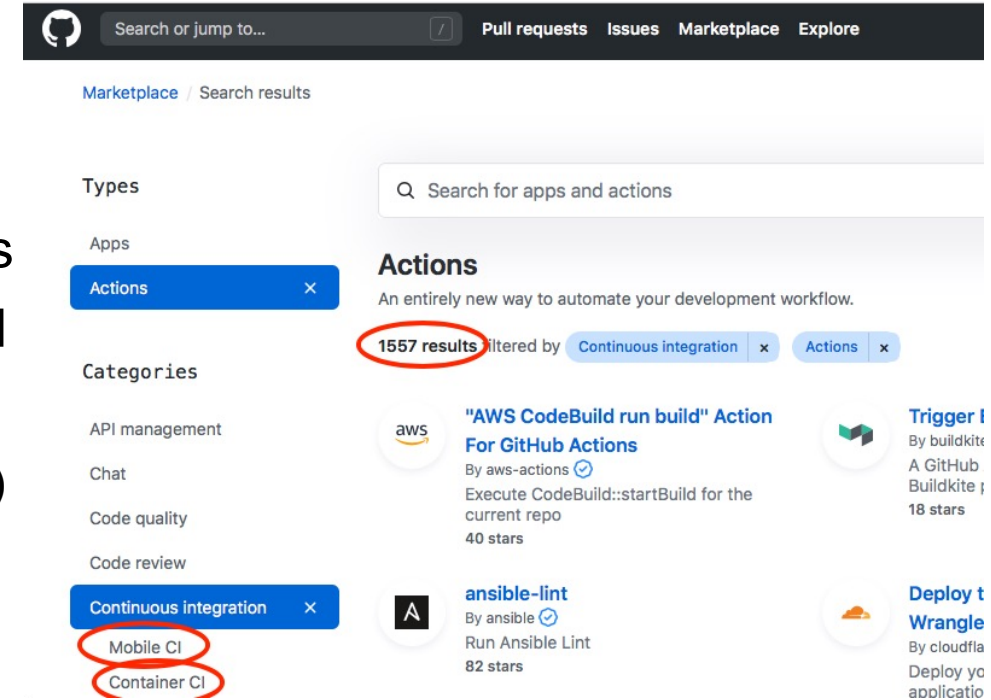
- Free Resources

- GitHub, BitBucket, GitLab, etc. provide shared runners
- AWS, Azure Pipelines have free tiers that can be used
- All launch a VM (Linux variants, Windows and OSX)
  - Constrained in time/size, hardware (e.g. GPU type/count)
  - Not a complete solution for many HPC/scientific codes, but a useful starting point.

- Site-local Resources

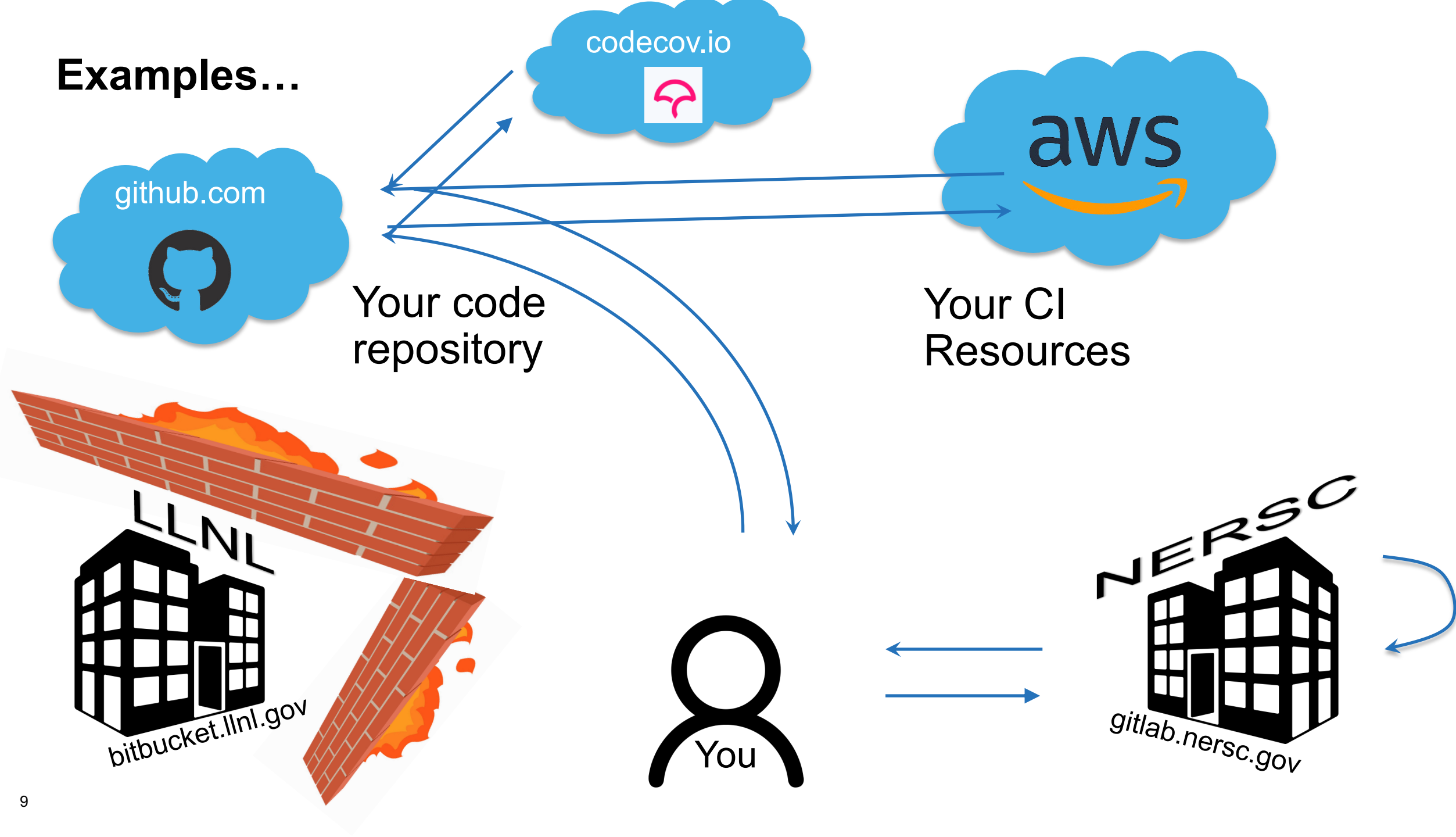
- Group, department, institution, computing facility
- Examples: CADES @ ORNL, Bamboo @ LLNL, Jenkins @ ANL, Travis+CDash @ NERSC
- ECP Program: GitLab-CI @ ANL, LANL, LLNL, NERSC, ORNL, SNL

- Create your own by setting up resources/services





# Examples...



# 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
  - At a minimum, even just building the code can be a place to start!
  - Once you’ve got the basics working, its easy to build up from there

# Getting started with CI:

Setting up CI

Service	Interface	
GitHub Actions	Repo YAML file	.github/workflows/<test_name>.yaml
GitLab	Web page configurator + repo YAML file [& repo scripts]	/.gitlab-ci.yml in root of repo
Bamboo	Web page configurator + repo scripts	
Travis	repo YAML file [& repo scripts]	/.travis.yml in root of repo

bssw-tutorial / hello-numerical-world Template

<> Code Issues 3 Pull requests 5 Actions

## Get started with GitHub Actions

Build, test, and deploy your code. Make code reviews, branch management, and issue triaging work the way you want. Select a workflow template to get started.

Skip this and [set up a workflow yourself](#) →

### C/C++ with Make

By GitHub Actions

Build and test a C/C++ project using Make.

Set up this workflow

```
./configure
make
make check
```

actions/starter-workflows

# Getting started with GitHub Actions:

19 lines (15 sloc) | 359 Bytes

```
1  name: Check Results
2
3  on:
4    push:
5      branches: [ main ]
6    pull_request:
7      branches: [ main ]
8
9  jobs:
10   build:
11
12     runs-on: ubuntu-latest
13
14     steps:
15     - uses: actions/checkout@v2
16     - name: make coverage
17       run: make CXXFLAGS=--coverage LDFLAGS="--coverage -lm" check_all
18     - name: upload coverage
19       run: bash <(curl -s https://codecov.io/bash)
```

# github.com

CodeIssuesPull requests**Actions**Projects...

Added workflows.

✓ Check Results #1

✓ build ▾

succeeded 4 minutes ago in 7s

> ✓ Set up job2s

> ✓ Run actions/checkout@v21s

▾ ✓ make coverage3s

1 ▶ Run make CXXFLAGS=--coverage LDFLAGS="--coverage -lm" check\_all

4 g++ -c --coverage heat.C -o heat.o

5 g++ -c --coverage utils.C -o utils.o

6 g++ -c --coverage args.C -o args.o

7 g++ -c --coverage exact.C -o exact.o

# codecov.io

ghmarkcmiller86hello-numerical-worldDocsSupportBlog•

fix error threshold

markcmiller86

3 hours ago

✓ CI Passed

51.60%

26d69cd

main

d24c2f3

📄📁📦📊

Files	Coverage
<a href="#">Double.H</a>	65.63%
<a href="#">args.C</a>	82.05%
<a href="#">crankn.C</a>	0.00%
<a href="#">exact.C</a>	0.00%
<a href="#">ftcs.C</a>	100.00%
<a href="#">heat.C</a>	73.81%
<a href="#">upwind15.C</a>	0.00%
<a href="#">utils.C</a>	49.35%
<b>Project Totals</b> (8 files)	<b>51.60%</b>

CALE  
UTING  
ECT

13

# GitHub Actions – results of workflow test runs

## Workflows

- All workflows
- (TEST) Pyomo Windows Tests ...
- (WIP) Pyomo Windows Test (P...
- (WIP) Pyomo Windows Test (P...
- (WIP) Pyomo Windows Tests (...)
- (WIP) Windows Pip Cmd Pyom...
- GitHub Branch CI
- GitHub CI
- Pyomo Release Distribution Cr...
- Python package
- Ubuntu Pyomo Single Python ...
- Ubuntu Pyomo Workflow (Slim,...

## GitHub CI

Showing runs from all workflows named GitHub CI

event:push workflow:"GitHub CI"

461 workflow run results				Event ▾	Status ▾	Branch ▾	Actor ▾
✓	Merge pull request #1902 from jsiirola/fix-unittest-rc	main	20 hours ago	1h 3m 55s	...		
	GitHub CI #121: Commit 901b487 pushed by blnicho						
✓	Merge pull request #1901 from mrmundt/remove-six	main	2 days ago	1h 3m 12s	...		
	GitHub CI #117: Commit a101b6d pushed by mrmundt						
✓	Merge pull request #1896 from jsiirola/abstract-disa...	main	2 days ago	1h 5m 39s	...		
	GitHub CI #112: Commit 1f9dd19 pushed by jsiirola						
✗	Merge pull request #1898 from mrmundt/py-unittest	main	3 days ago	1h 3m 33s	...		
	GitHub CI #109: Commit 1beb848 pushed by michaelbynum						
✓	Merge pull request #1893 from jsiirola/config-enum	main	3 days ago	1h 11m 3s	...		
	GitHub CI #105: Commit 9aa1186 pushed by jsiirola						

# GitHub Pull Request Status Indicators

Filters ▾

🔍

is:pr is:open

🏷️ Labels

26

📌 Milestones

3

New pull request

🔗 17 Open

✓ 1,018 Closed

Author ▾

Label ▾

Projects ▾

Milestones ▾

Reviews ▾

Assignee ▾

Sort ▾

🔗

Allow string args to external fuctions

✖

#1904

opened 19 hours ago by eslickj

• Review required

🔍 1

💬 1

🔗

Port Cloning

✓

#1899

opened 3 days ago by michaelbynum

• Approved

🔍 1

💬 3

🔗

Remove pyomo.solvers.tests.core

✓

#1897

opened 3 days ago by mrmundt

• Approved

💬 2

🔗

[WIP] Model partition package

●

#1895

opened 4 days ago by rahuljoglekar47

• Review required

💬 1



# Summary

- The purpose of CI is to identify problems early
  - Prevent code that would “break the build” or adversely impact other developers being introduced
  - Need to provide sufficient confidence, but run quickly – balance varies by project
- CI should complement (not replace) more extensive automated testing
  - Use scheduled testing for more and more detailed tests, more configurations and platforms, performance testing, etc.
- CI for TDD is a natural fit
  - Writing tests before the code works well with CI
- Many options for where to execute CI tests
  - Free services are a good (easy) place to start
  - But may not be sufficient in the long run (especially large HPC/scientific codes)
- Start simple to get automation working, then build out what you need
  - Focus initially on key software configurations and aspects of the code to be tested
  - Make sure your testing expands to cover new code, use TDD