Code Coverage and Continuous Integration

Presented at
Better Scientific Software tutorial

ECP 2nd Annual Meeting, Knoxville, Tennessee

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NNSA National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY | Office of Science
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License, citation and acknowledgements

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Code Coverage

How do we determine what other tests are needed?

Code coverage tools

- Expose parts of the code that aren't being tested
- gcov
  - standard utility with the GNU compiler collection suite
  - compile with --coverage
  - counts the number of times each statement is executed
- lcov
  - a graphical front-end for gcov
  - available at http://ltp.sourceforge.net/coverage/lcov.php
- Hosted servers (*e.g.* coveralls, codecov)
  - graphical visualization of results
  - push results to server through continuous integration server

Code coverage output

Overall Analysis

SOURCE FILES ON BUILD 45

LIST 2 CHANGED 0 SOURCE CHANGED 0 COVERAGE CHANGED 0

COVERAGE	Δ	FILE	LINES	RELEVANT	COVERED
74.39		src/functions/linear_fcn_class.f90	301	82	61
100.0		src/general/modulo_mod.f90	52	3	3

Detailed Analysis

```
265         ! Error distribution same for all x values
266         delta = S*Sxx - Sx*Sx
267         if (delta == 0.0_wp) then
268             ERRORMSG("Cannot do linear least-sqrs.  Divide by zero.")
269             stop
270         end if
271         delta_inv = 1.0_wp / delta
```

Online tutorial - https://github.com/amklinv/morpheus

Other example - https://github.com/jrdoneal/infrastructure

Code coverage is popular

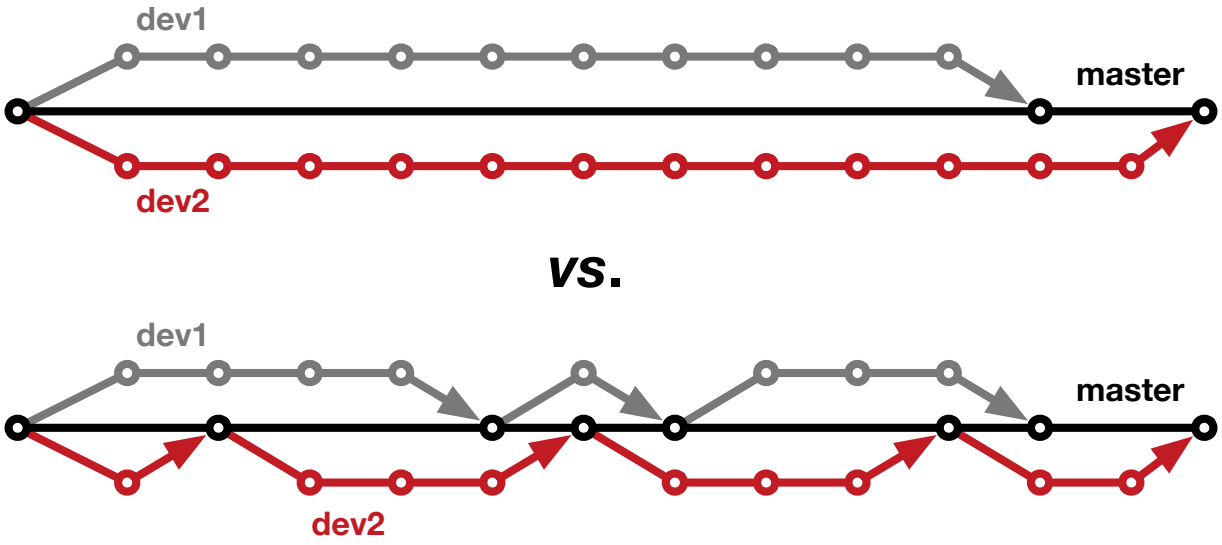
- gcov also works for C and Fortran
- Other tools exist for other languages
  - JCov for Java
  - Coverage.py for python
  - Devel::Cover for perl
  - profile for MATLAB
  - *etc*.

Continuous integration

The Short & Sweet of Continuous Integration

A master branch that always works

- Develop workflow policies
  - Commit and merge often
  - Test on push & pull requests?
- Code changes trigger automated builds/tests on target environments



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Continuous integration (CI)

- Has existed for some time and interest is growing
  - ECP working with Travis CI to adapt for HPC machines
  - Dedicated Breakout Session

Thursday, February 8, 2018

10:30 AM-12:00 PM	**Breakout Sessions Track 1** **B-HI-9 | Ballroom B |** Continuous Integration Testing for ECP: An Essential Software Development Tool

- Setup, maintenance, and monitoring required
- Prerequisites
  - A reasonably automated build system
  - An automated test system with significant test coverage & useful feedback
  - Ability to bundle subset of tests
  - Builds/tests must finish in reasonable about of time

Cloud-based CI

- Linked to VCS hosts
  - GitHub & Travis CI
  - GitLab CI
  - BitBucket Pipelines
- Automated builds/tests triggered *via* pushes and pull requests
- Builds/tests can be run on cloud systems
- Test results are reported on the pull request page
- Can trigger code coverage analysis & documentation build
- Run tests on different environments

View of toy repository

https://github.com/jrdoneal/infrastructure

Repository Root

documentation	Included proper location of folders
src	Convert line_t into a class and impr
.gitignore	Travis CI should now run code cove
.travis.yml	Convert line_t into a class and impr
Makefile	Dont delete html or html/.git as this
README.md	Update README.md

README.md

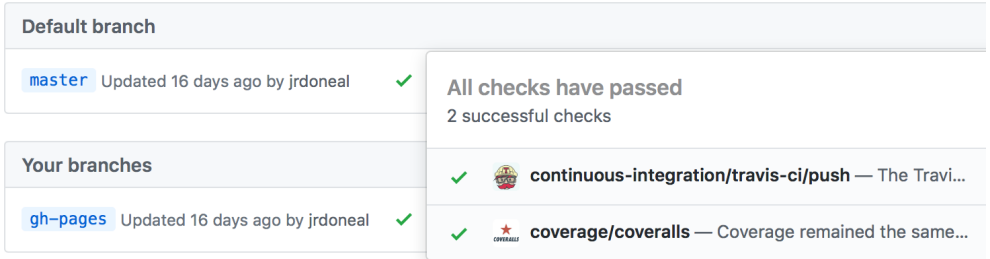
Sample .travis.yml

```
1  language: cpp
2
3  os:
4    - linux
5    - osx
6
7  compiler:
8    - g++
9    - clang
10
11 script: make && ./runtests.pl
```

Status of Personal codebase

Updated automatically

Results of CI Actions



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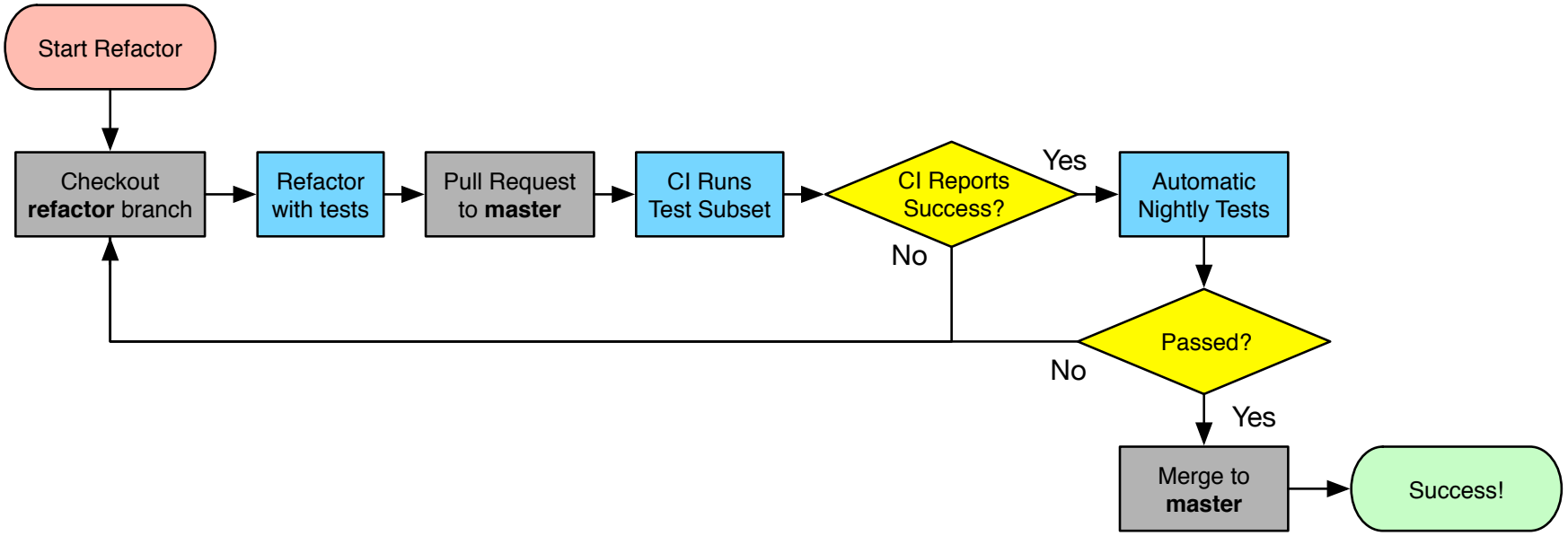
Putting it all together

Toy CI Workflow



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Other resources

Software testing levels and definitions:
http://www.tutorialspoint.com/software_testing/software_testing_levels.htm

Working Effectively with Legacy Code, Michael Feathers. The legacy software change algorithm described in this book is very straight-forward and powerful for anyone working on a code that has insufficient testing.

Code Complete, Steve McConnell. Includes testing advice.

Organization dedicated to software testing: https://www.associationforsoftwaretesting.org/

Software Carpentry: http://katyhuff.github.io/python-testing/

Tutorial from Udacity: https://www.udacity.com/course/software-testing--cs258

Papers on testing:
http://www.sciencedirect.com/science/article/pii/S0950584914001232
https://www.researchgate.net/publication/264697060_Ongoing_verification_of_a_multiphysics_community_code_FLASH

Resources for Trilinos testing:
Trilinos testing policy: https://github.com/trilinos/Trilinos/wiki/Trilinos-Testing-Policy
Trilinos test harness: https://github.com/trilinos/Trilinos/wiki/Policies--%7C-Testing

Agenda

Time	Topic	Speaker
1:30pm-2:15pm	Why effective software practices are essential for CSE projects	Anshu Dubey, ANL
2:15pm-2:45pm	Better (small) scientific software teams	Michael A. Heroux, SNL
2:45pm-3:00pm	Improving Reproducibility Through Better Software Practices	Michael A. Heroux, SNL
3:00pm-3:30pm	Break	
3:30pm-4:15pm	Testing HPC Scientific Software: Introduction	Jared O'Neal, ANL
4:15pm-4:45pm	Verification, and Evaluating Project Testing Needs	Anshu Dubey, ANL
4:45am-5:00pm	Code Coverage and CI	Jared O'Neal, ANL