A Crash Course for SU2 Hackers

Dr. Thomas D. Economon

3rd Annual SU2 Developers Meeting
University of Strathclyde
September 16, 2018

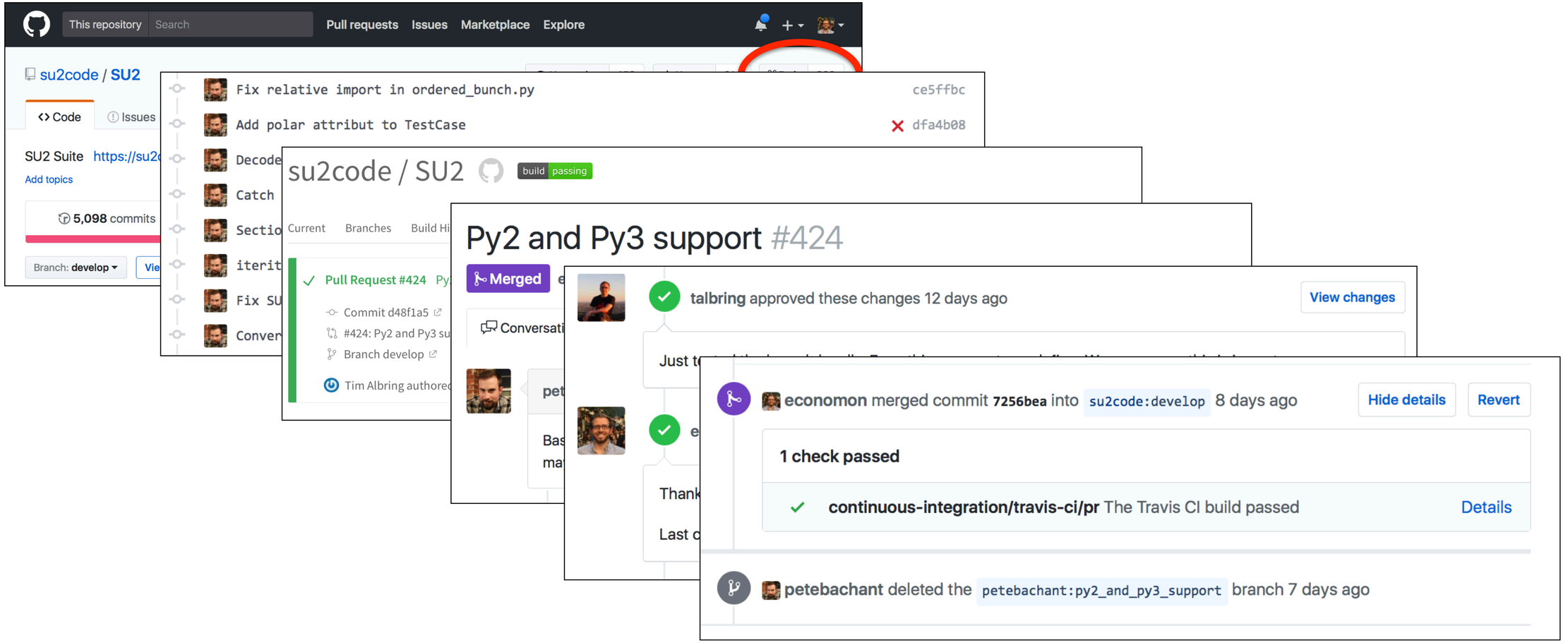
So, you want to be an SU2 developer?

Good news: it's easy.

We leverage standard development processes and the latest tools for open-source projects.

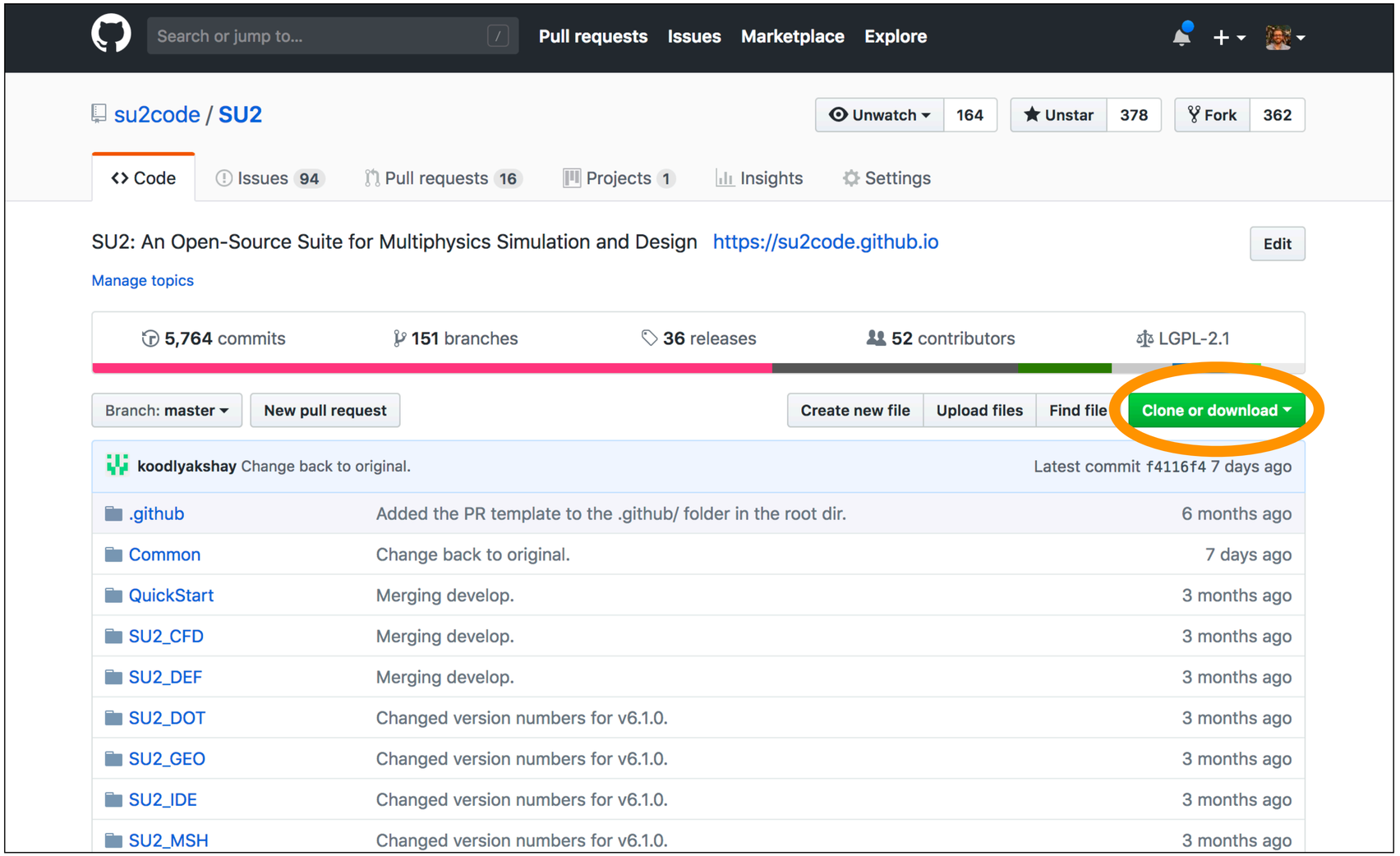
You will be ready to hack at the end of this talk.

Git/Branching Development Regressions Pull Request Release



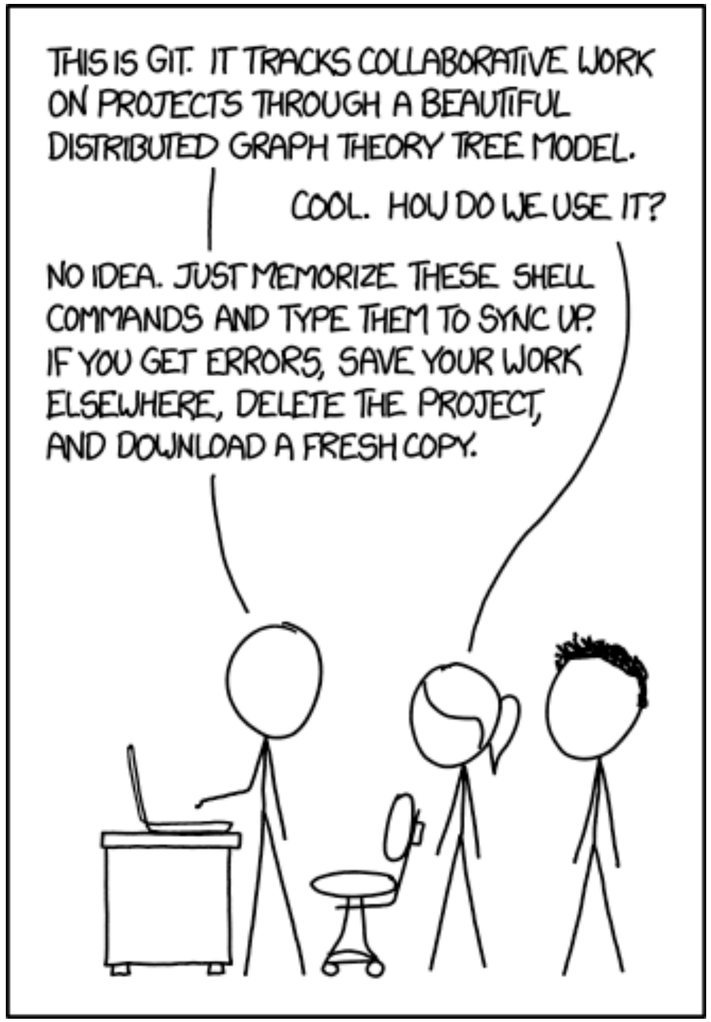
Anyone can be an SU2 developer.

Git/Branching — Development — Regressions — Pull Request — Release



Your starting point: https://github.com/su2code/SU2.

Git/Branching Development Regressions Pull Request Release



http://xkcd.com/1597/

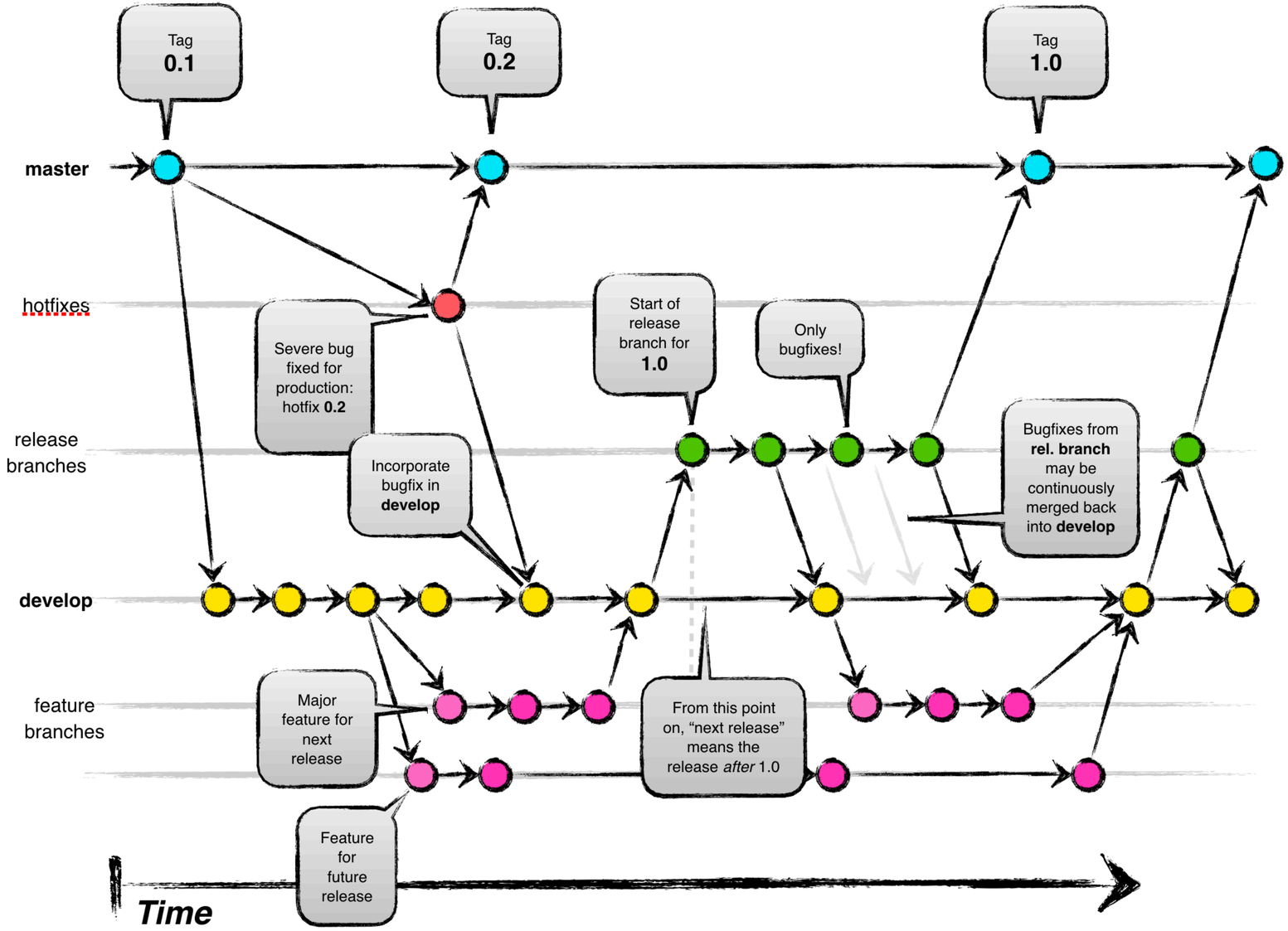
Here's that list of shell commands you should memorize:

- $ git clone https://github.com/su2code/SU2.git
- $ git branch
- $ git checkout -b feature_awesome origin/feature_awesome
- $ git status
- $ git diff
- $ git commit -am "This is an awesome commit."
- $ git push origin feature_awesome
- $ git checkout develop
- $ git pull origin develop
- $ git merge develop

And their translations:

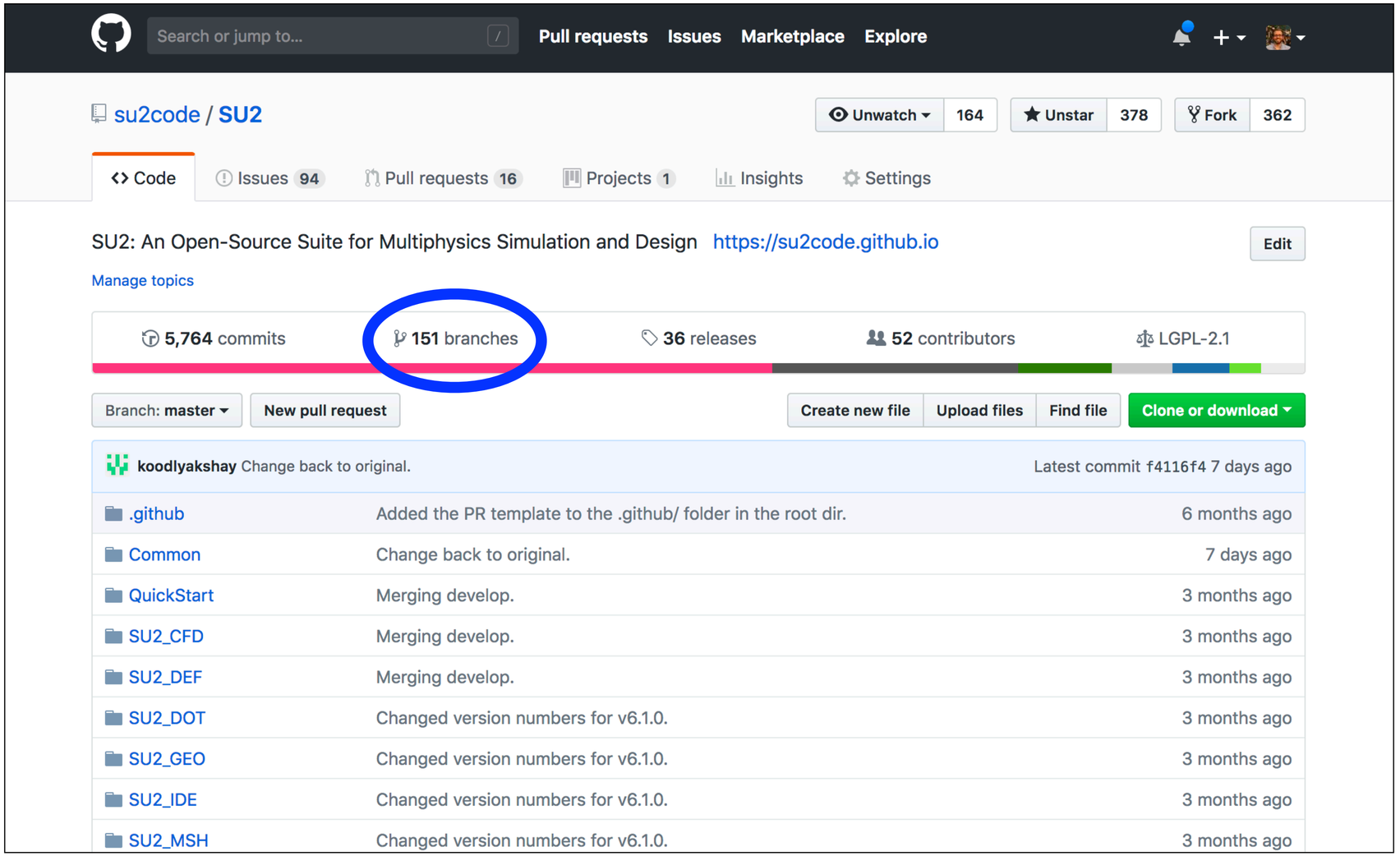
- Get a fresh copy of the entire repo (master branch to start)
- Check which branches I have locally
- Check out my feature branch that is already on the remote
- Check which files have changed since last commit
- Detailed diff of code changes since last commit
- While working, make commits frequently with messages
- Regularly push to the remote on GitHub
- Switch to the develop branch (assuming you have it locally)
- Merge the changes in the remote develop into local develop
- Merge the changes from local develop into current local branch

We use the popular Gitflow branching model.



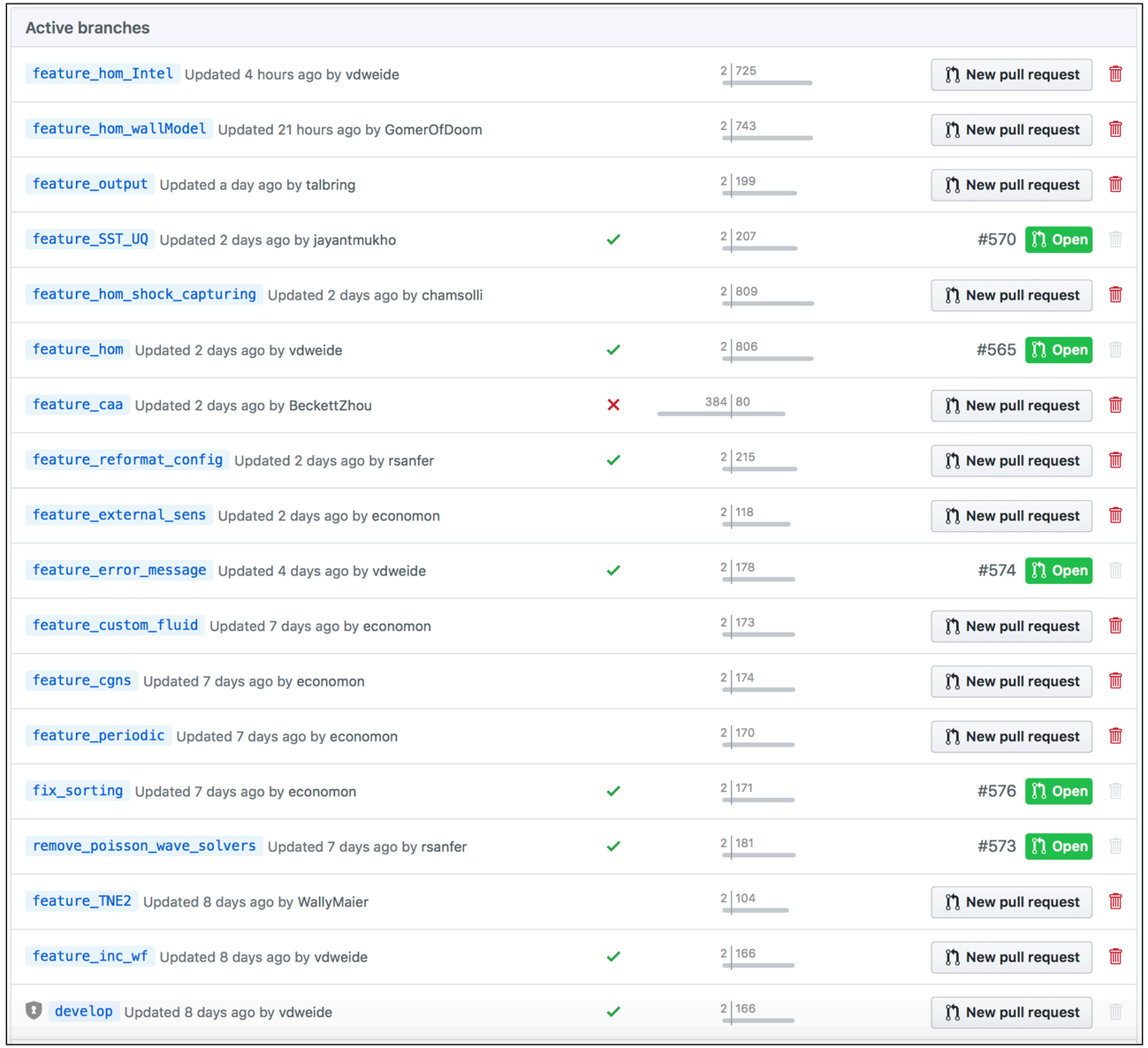
Author: Vincent Driessen
Original blog post: http://nvie.com/archives/323

Git/Branching — Development — Regressions — Pull Request — Release



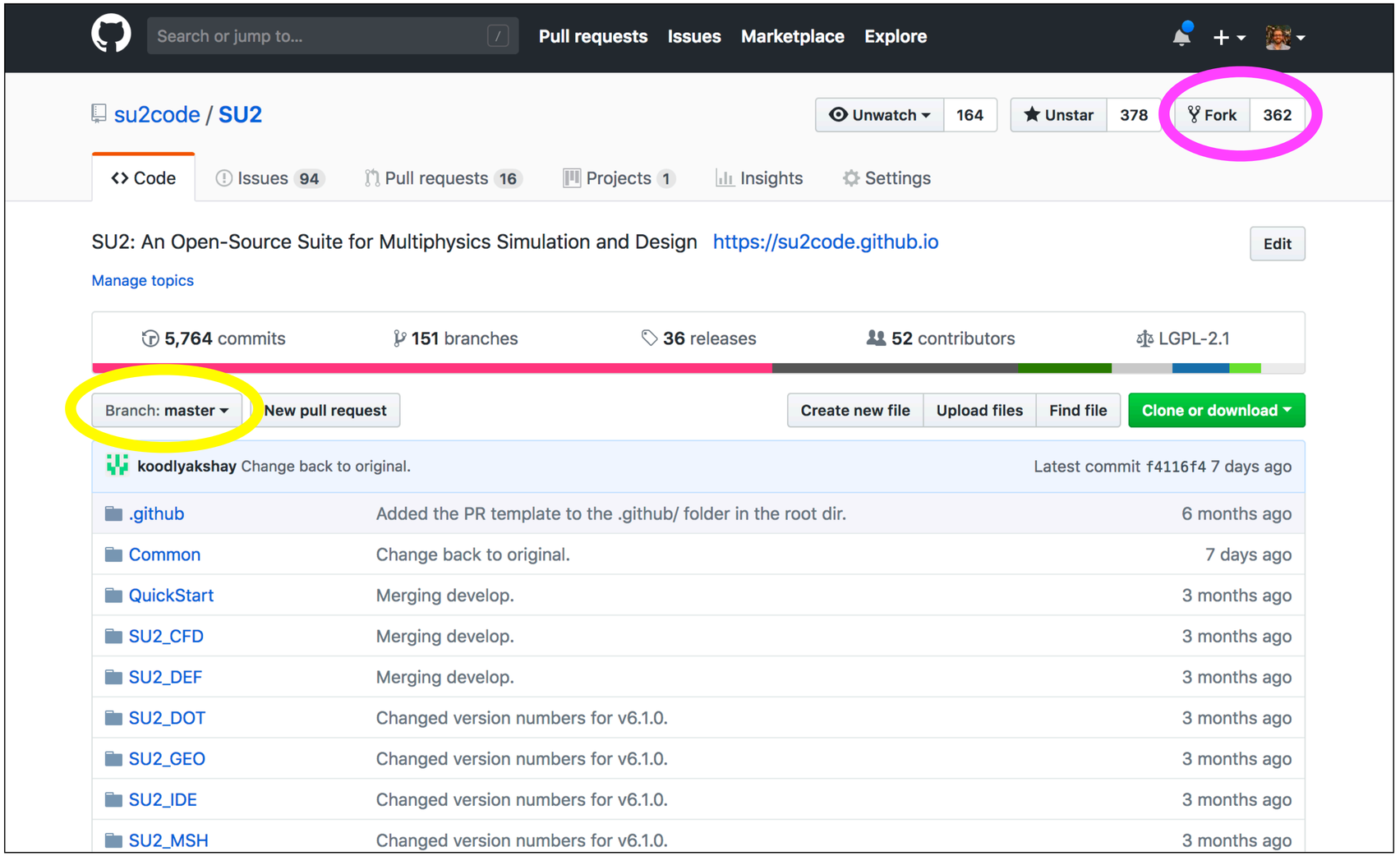
See all of our public repo branches here.

Git/Branching — Development — Regressions — Pull Request — Release



A current snapshot of active branches

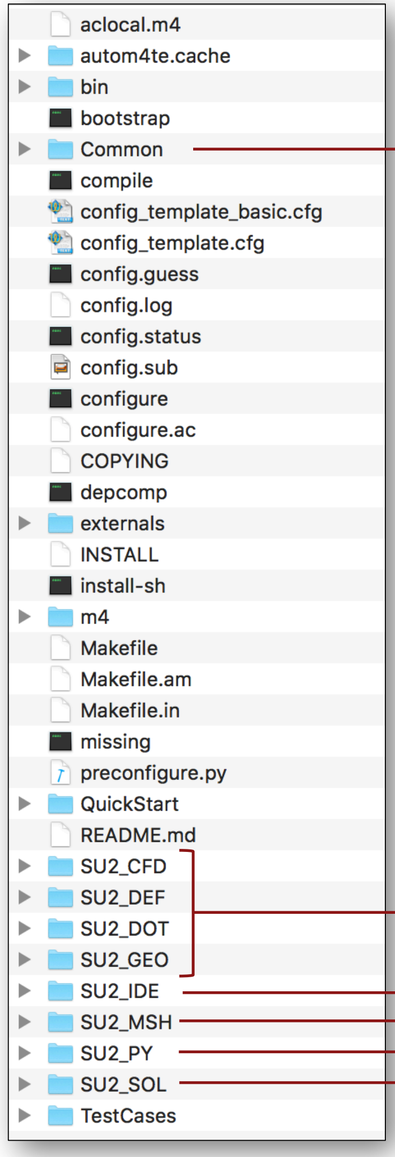
Note that develop is a protected branch



New branches can be made in the browser interface here or by pushing local branches to the remote with git.

Git/Branching — Development — Regressions — Pull Request — Release

Here is what you see inside the SU2/ repo.



Run ./bootstrap to reset autotools

Template config file with all options

External source files, e.g., ParMETIS

Inviscid NACA 0012

Config files for tests

C++ Source Code in SU2_*/src/, majority of lines in Common/src/ & SU2_CFD/src

IDE project files, e.g., Xcode

Python Scripts

C++ Executables

- SU2_CFD -> Primary multiphysics PDE solver for primal and adjoint
- SU2_SOL -> Solution export code
- SU2_DEF -> Mesh deformation
- SU2_DOT -> Gradient projection
- SU2_GEO -> Geometry definition
- SU2_MSH -> Mesh adaptation

Python Scripts (just a subset of them)

- parallel_computation.py
- mesh_deformation.py
- shape_optimization.py
- continuous_adjoint.py
- discrete_adjoint.py
- finite_differences.py
- direct_differentiation.py

- C++ class abstractions encourage code reuse and data encapsulation ensures you can make localized changes easily.

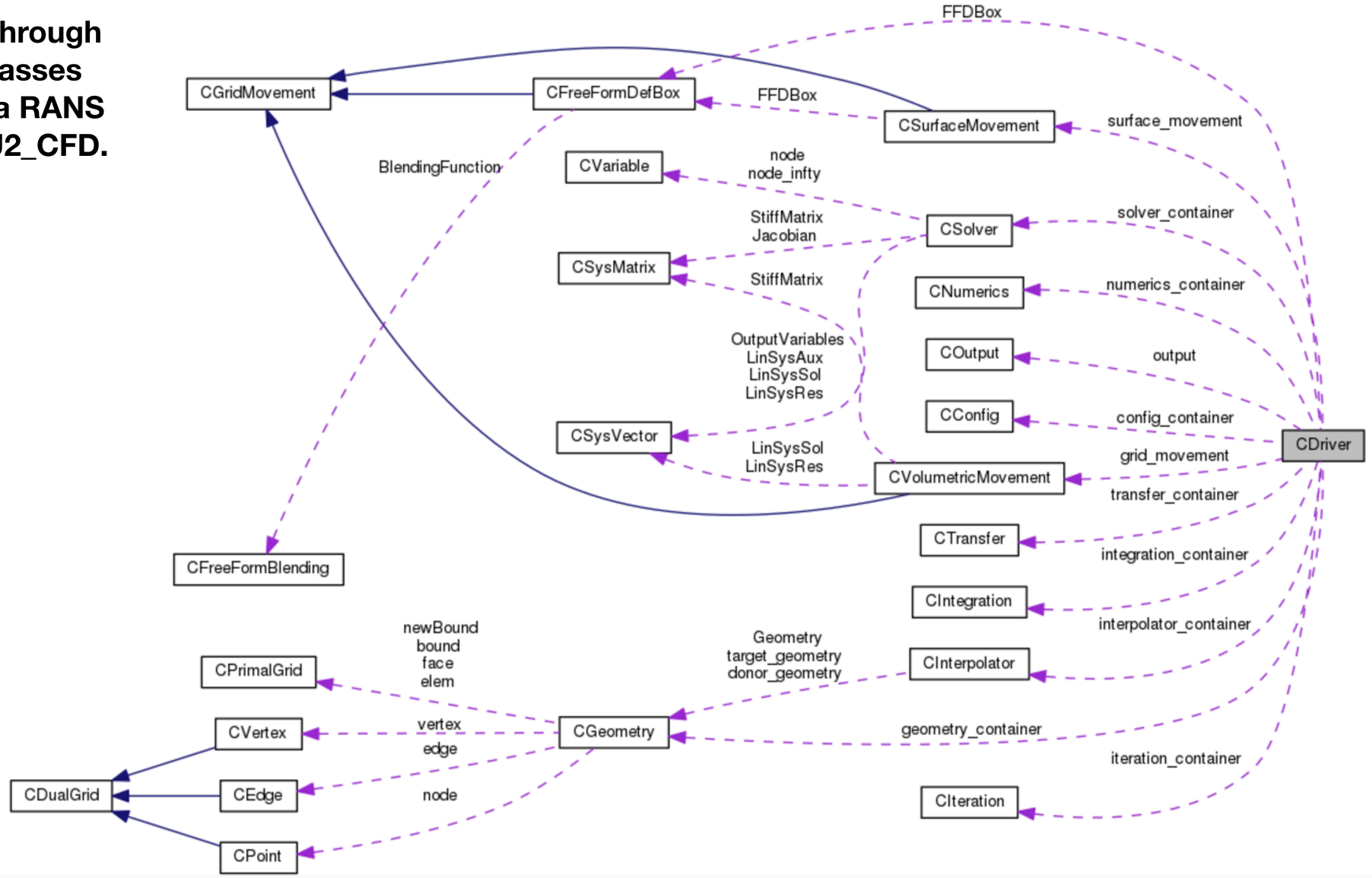
- Common base classes/methods (grid, linear solvers, output, etc.) are reused for many sets of physical governing equations.

- For a particular PDE, we define iteration, numerics, solver, and variable classes that are customized for the particular methods and algorithms.

  - Files with *_structure.cpp contain base classes.

  - Files with solver_*.cpp, variable_*.cpp, numerics_*.cpp, contain child classes for a particular PDE, e.g., solver_direct_mean.cpp for mean flow.

Top-down walkthrough of some key classes instantiated for a RANS calculation in SU2_CFD.



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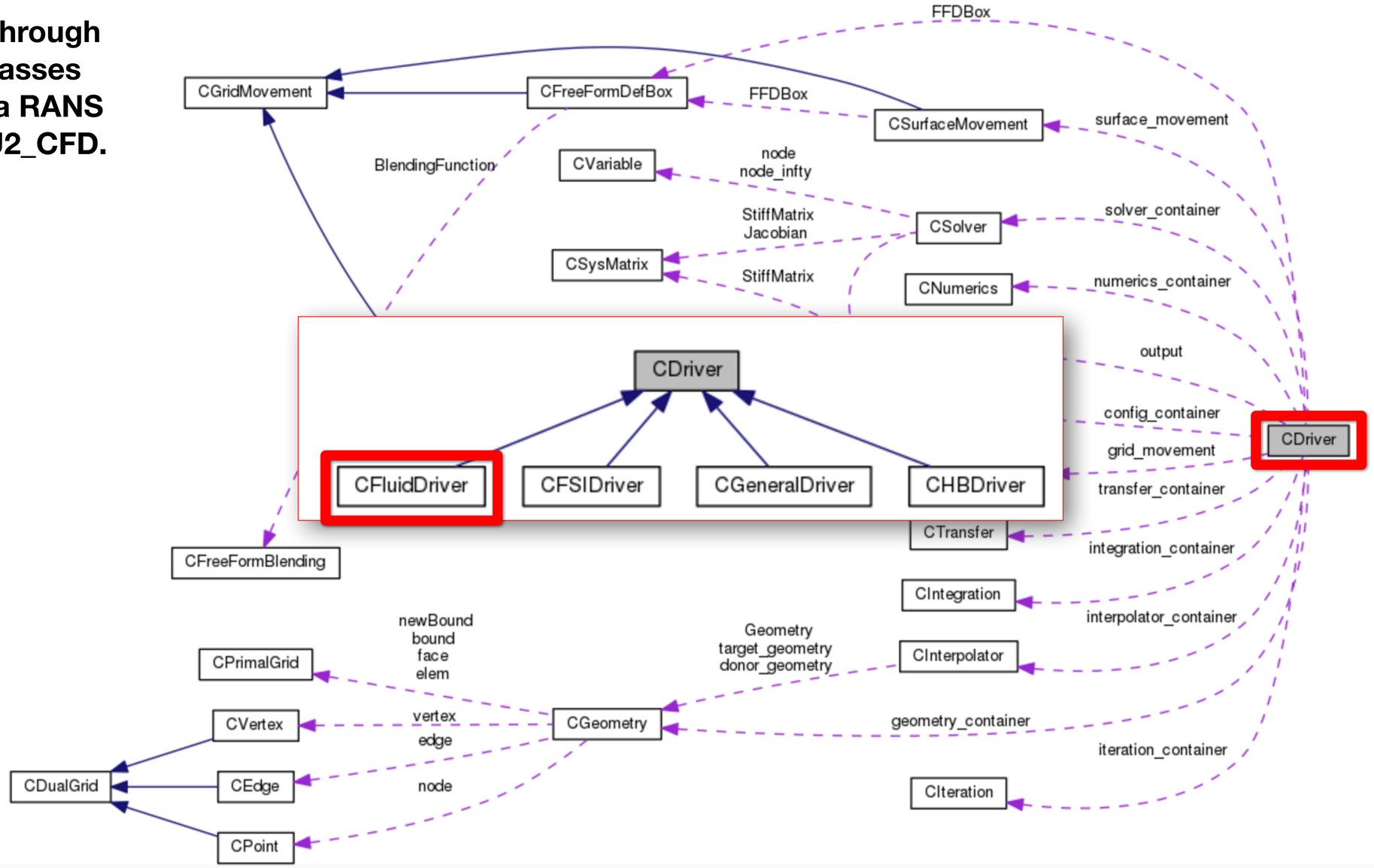

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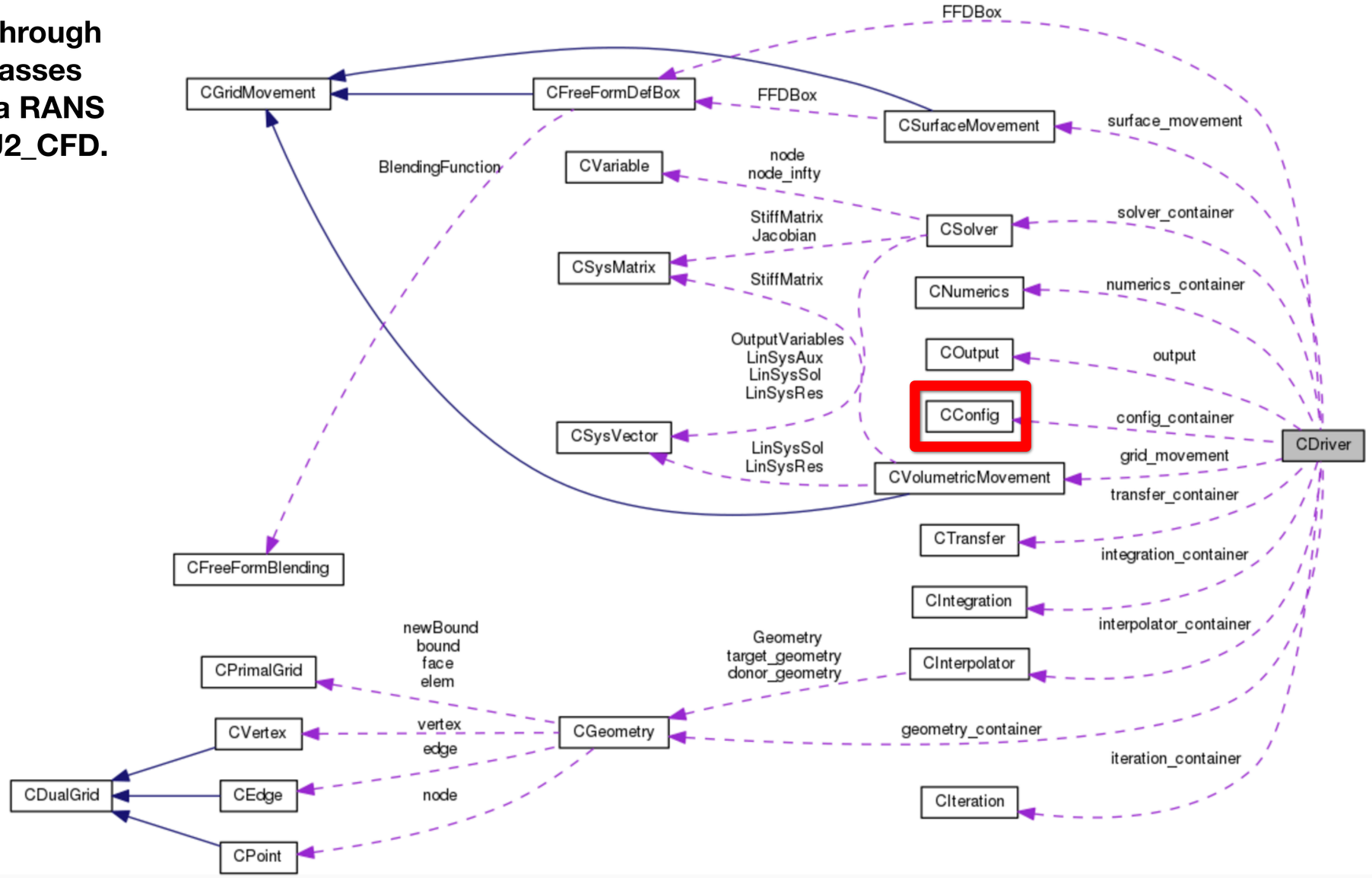

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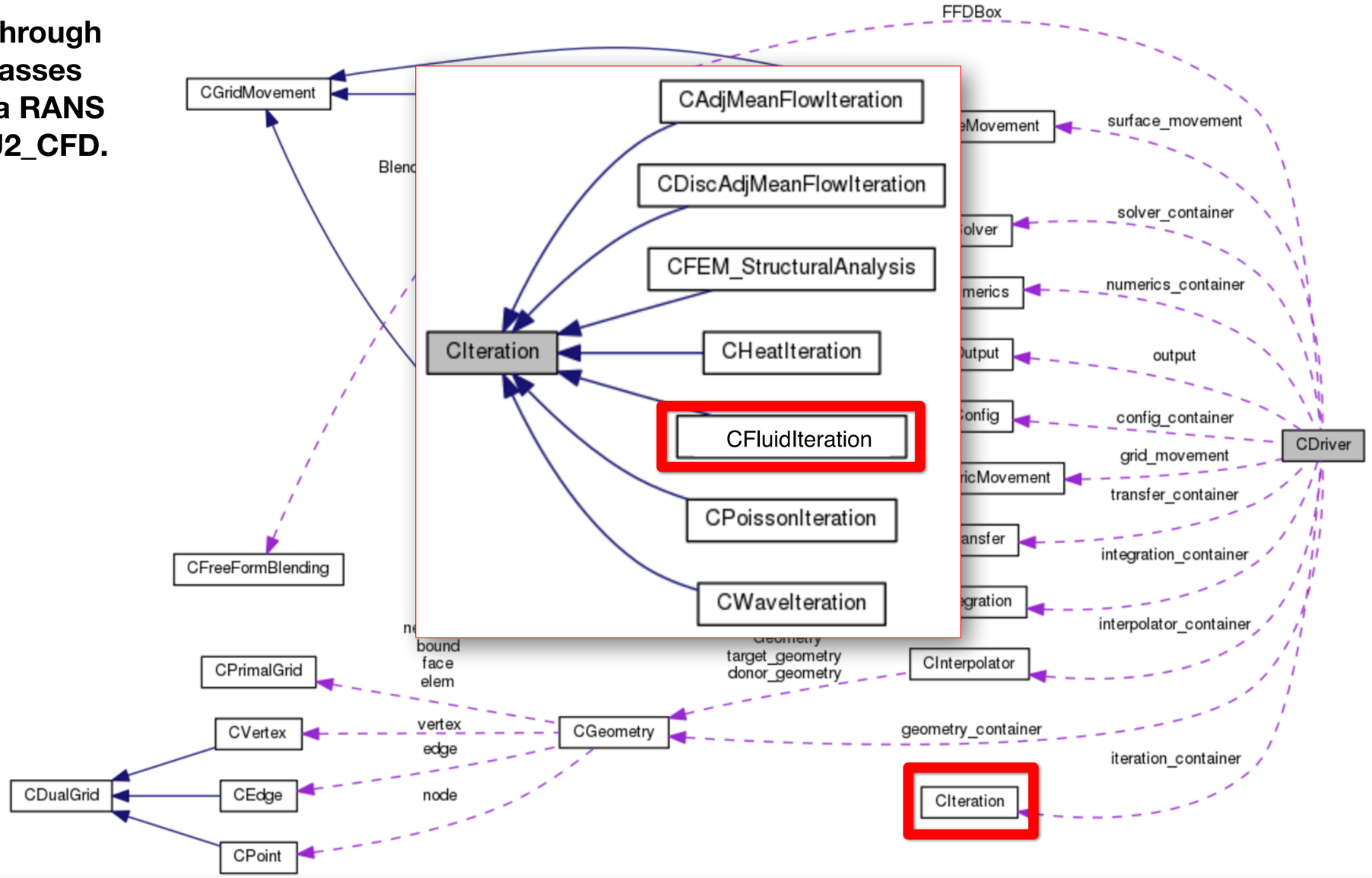

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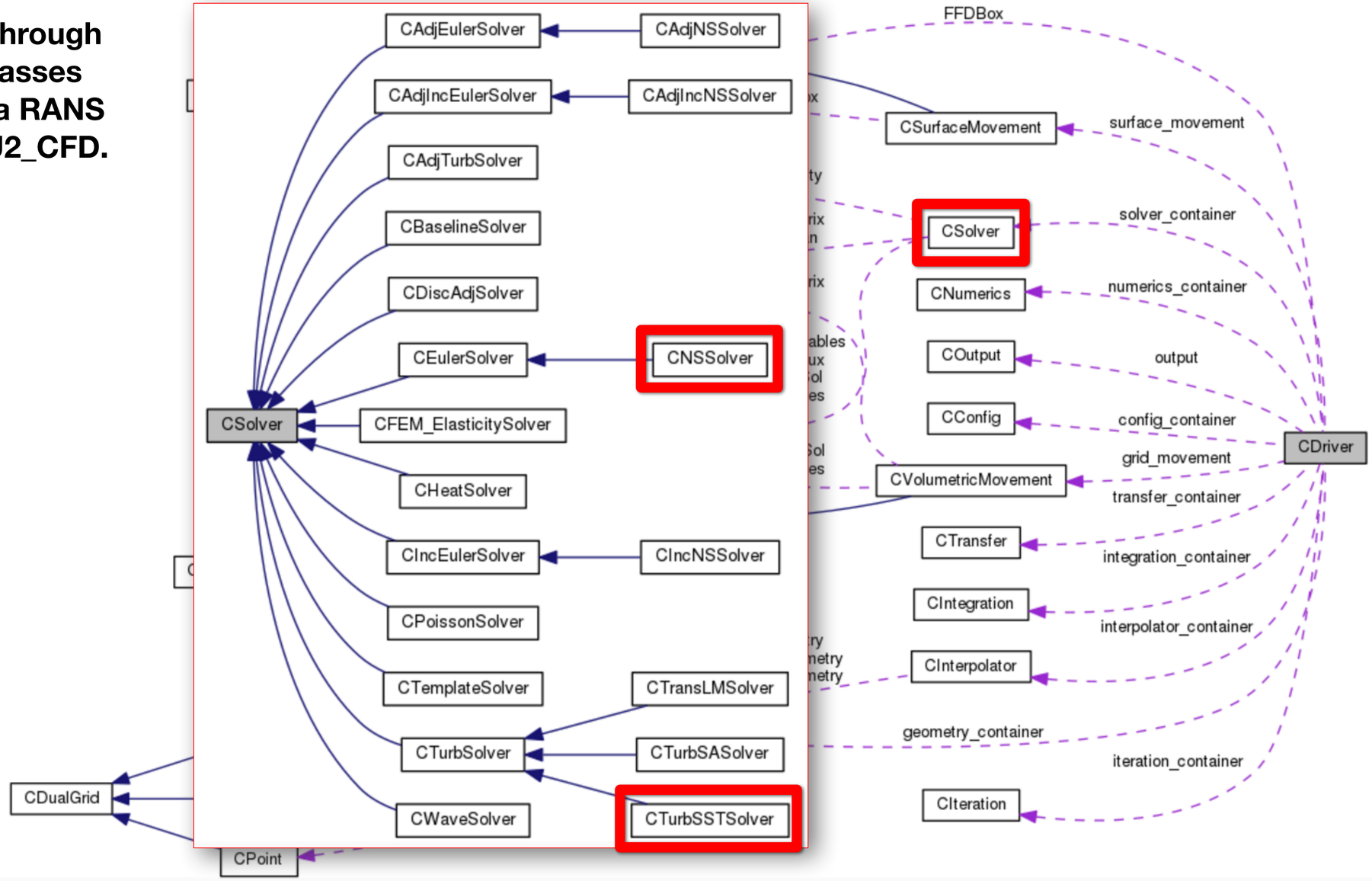

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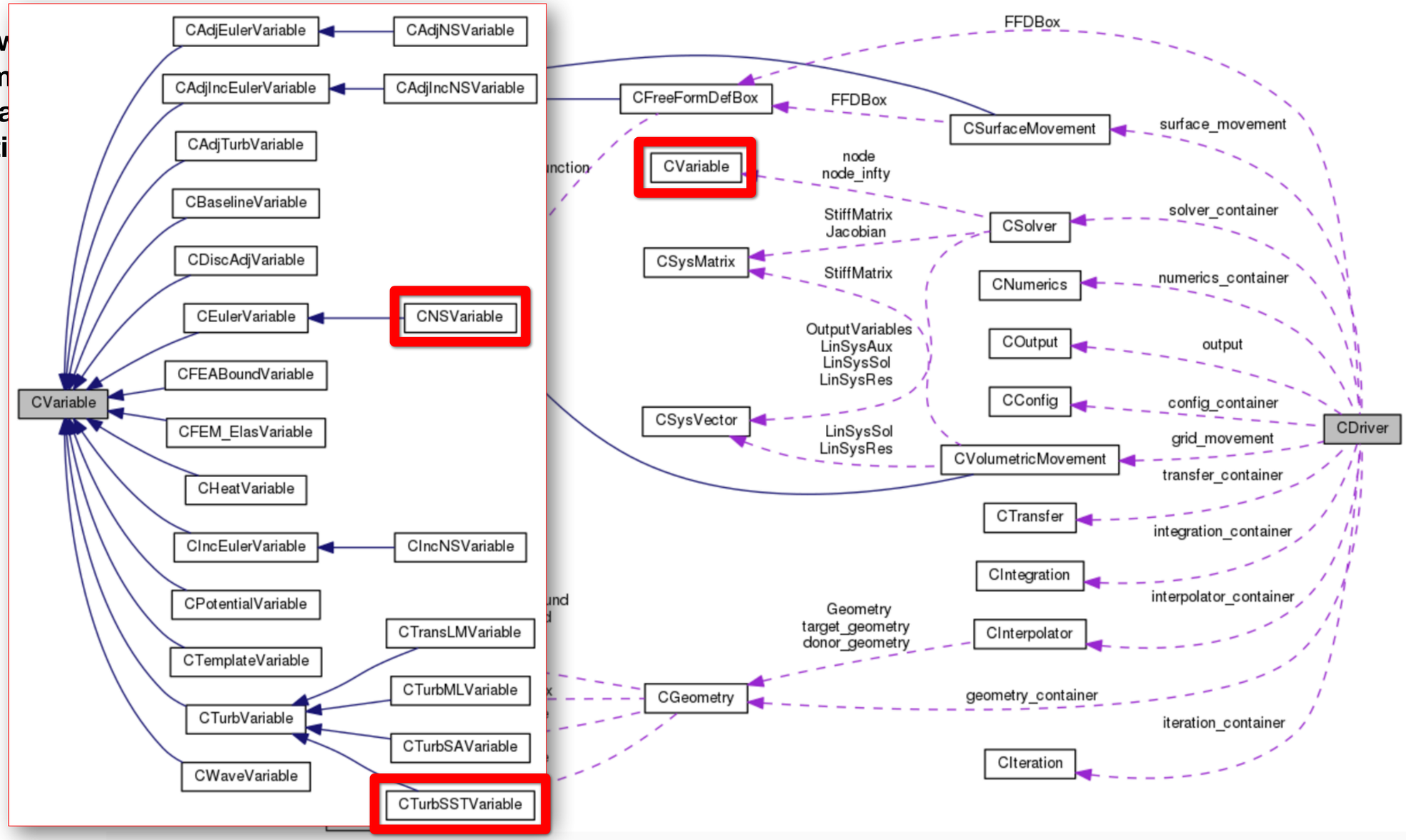

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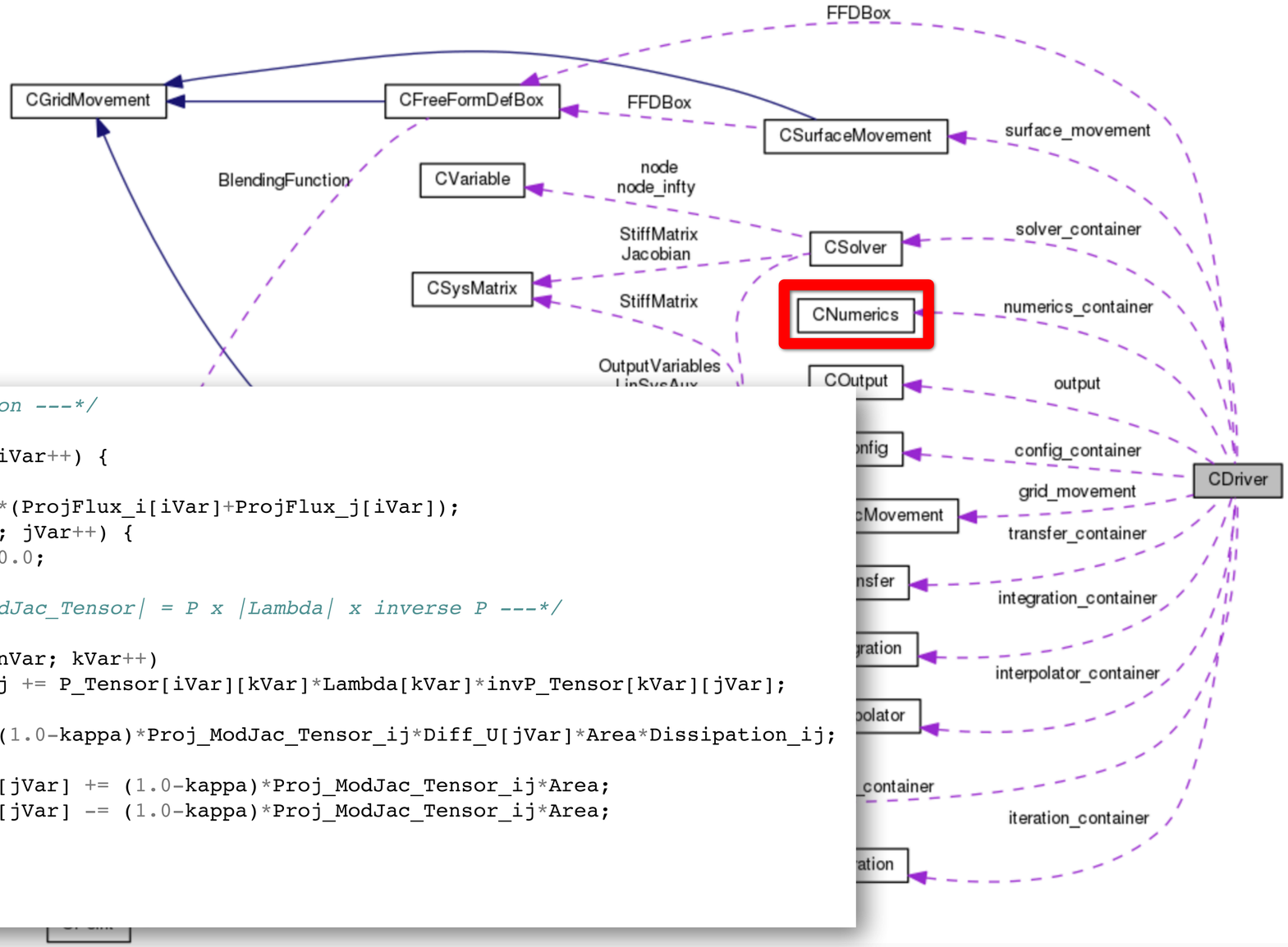
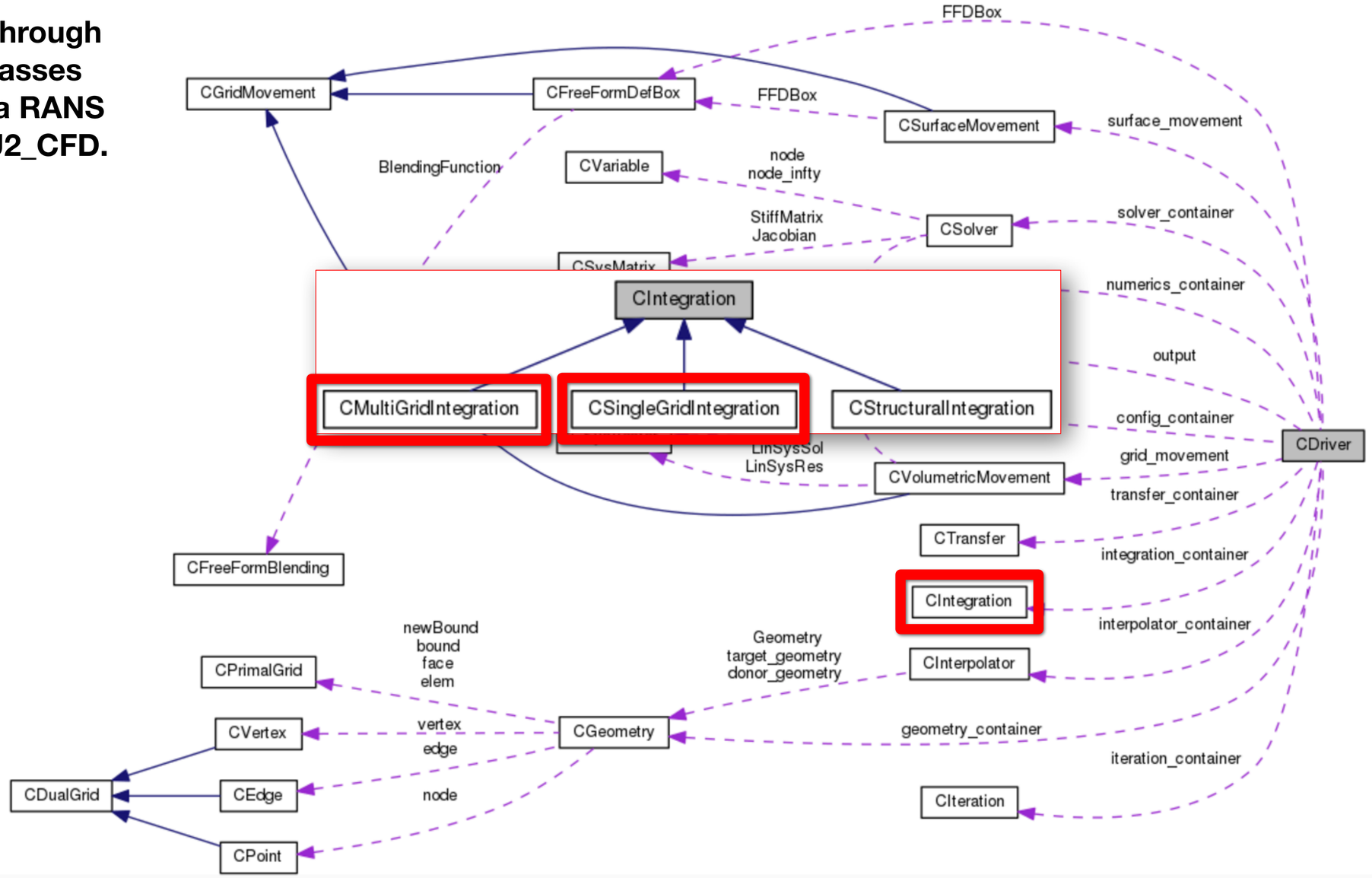



```
/*--- Roe's Flux approximation ---*/

for (iVar = 0; iVar < nVar; iVar++) {

  val_residual[iVar] = kappa*(ProjFlux_i[iVar]+ProjFlux_j[iVar]);
  for (jVar = 0; jVar < nVar; jVar++) {
    Proj_ModJac_Tensor_ij = 0.0;

      /*--- Compute |Proj_ModJac_Tensor| = P x |Lambda| x inverse P ---*/

      for (kVar = 0; kVar < nVar; kVar++)
        Proj_ModJac_Tensor_ij += P_Tensor[iVar][kVar]*Lambda[kVar]*invP_Tensor[kVar][jVar];

      val_residual[iVar] -= (1.0-kappa)*Proj_ModJac_Tensor_ij*Diff_U[jVar]*Area*Dissipation_ij;
      if(implicit){
        val_Jacobian_i[iVar][jVar] += (1.0-kappa)*Proj_ModJac_Tensor_ij*Area;
        val_Jacobian_j[iVar][jVar] -= (1.0-kappa)*Proj_ModJac_Tensor_ij*Area;
      }
  }
}
```

Top-down walkthrough of some key classes instantiated for a RANS calculation in SU2_CFD.



Git/Branching Development Regressions Pull Request Release

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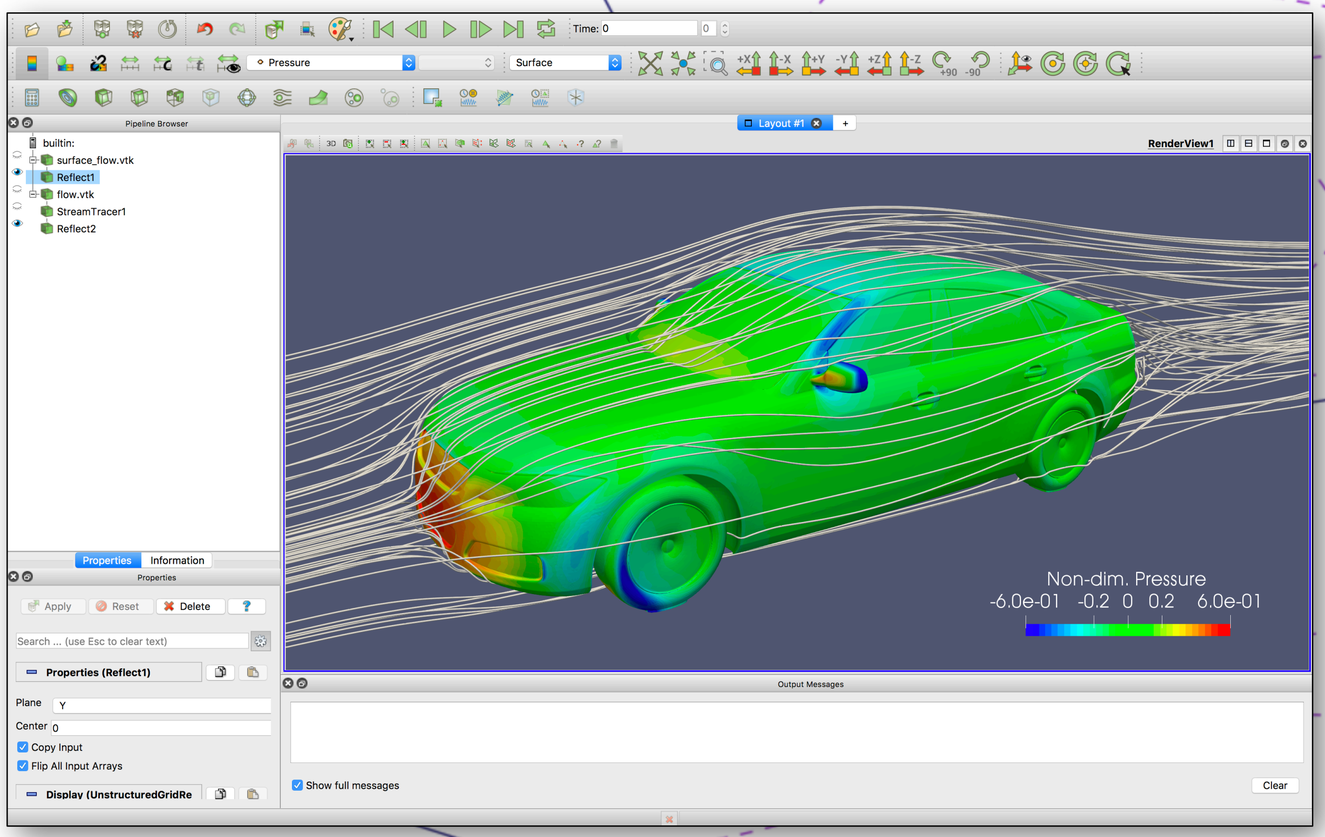


- Now that you know the basics, you are ready to create a new branch for your awesome feature (feature_awesome) and start hacking.

- But you might say, "Wait, how do I coordinate my contribution with other ongoing work in the repository?”

  - Posting **issues on GitHub** and interacting with the SU2 IDS are great ways to discuss potential developments and coordinate among other developers in the open.

- And then maybe you’ll ask, “How can I make sure that my work doesn’t ‘break’ other capabilities that already exist in SU2?”

  - **Continuous integration will save your bacon.** Travis CI is free for open-source!

Git/Branching — Development — Regressions — Pull Request — Release

SU2 (ver. 6.1.0 "Falcon"): The C

Computational analysis tools have revolutioniz
proprietary, unavailable, or prohibitively expen
analysis and design freely available as open-s

For an overview of the technical details in SU2

"SU2: An open-source suite for multiphysics s
http://arc.aiaa.org/doi/10.2514/1.J053813

build passing

Our security blanket: a comprehensive suite of ~200 regression test cases for serial, parallel, physics, AD, python, etc.

su2code / SU2 build unknown

Travis CI

Current Branches Build History Pull Requests Build #2312 More options

develop Merge pull request #575 from pecos-hybrid/bugfix_viscosity_in_FD

Change dynamic viscosity in FD hybrid central / upwind blending to kinematic viscosity

Commit d00c3b3
Compare a0ecddf..d00c3b3
Branch develop

Edwin van der Weide authored GitHub committed

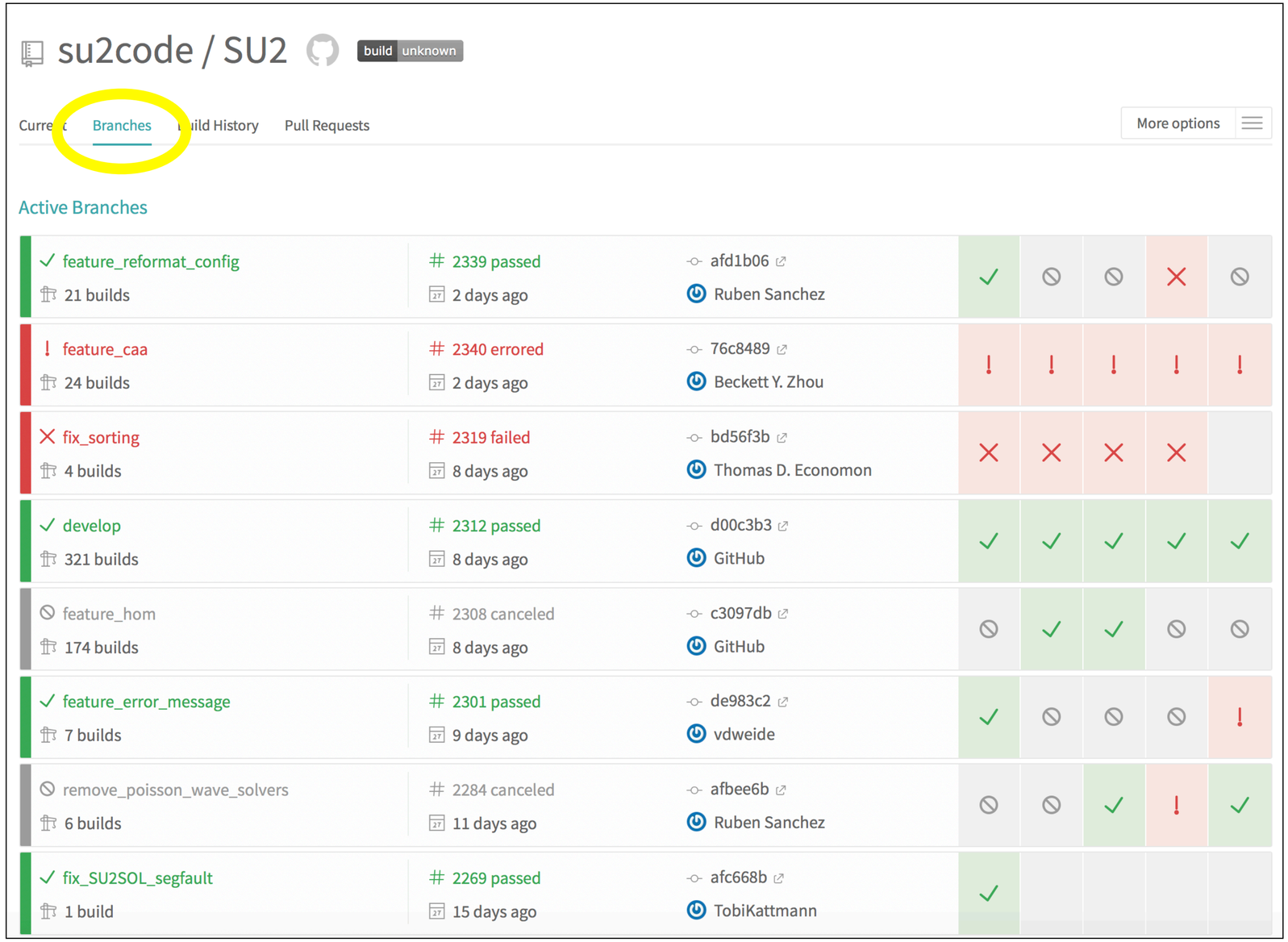
#2312 passed
Restart build
Ran for 2 hrs 5 min 54 sec
Total time 8 hrs 9 min 37 sec
8 days ago

Build Jobs

✓	2312.1	Python: 2.7	CONFIGURE_COMMAND="./preconfigure.py --prefix=$TRAVIS_BUI...	1 hr 3 min 49 sec
✓	2312.2	Python: 3.6	CONFIGURE_COMMAND="./preconfigure.py --prefix=$TRAVIS_BUI...	1 hr 3 min 25 sec
✓	2312.3	Python: 2.7	CONFIGURE_COMMAND="./preconfigure.py --enable-mpi --with-cc...	58 min 49 sec
✓	2312.4	Python: 3.6	CONFIGURE_COMMAND="./preconfigure.py --enable-mpi --with-cc...	58 min 31 sec
✓	2312.5	Python: 2.7	CONFIGURE_COMMAND="./preconfigure.py --with-cc=gcc --with-c...	1 hr 3 sec
✓	2312.6	Python: 3.6	CONFIGURE_COMMAND="./preconfigure.py --with-cc=gcc --with-c...	59 min 52 sec
✓	2312.7	Python: 2.7	CONFIGURE_COMMAND="./preconfigure.py --enable-mpi --with-cc...	1 hr 36 sec
✓	2312.8	Python: 3.6	CONFIGURE_COMMAND="./preconfigure.py --enable-mpi --with-cc...	1 hr 4 min 32 sec

Use continuous integration to guide your development by activating Travis CI for your own branches! Update SU2/.travis.yml with your own email and branch.

```
# Continous Integration setup for SU2.

dist: trusty
sudo: required

language: python

compiler:
    - gcc

notifications:
    email:
        recipients:
            - your.email@here.com

branches:
    only:
        - feature_awesome
```



New capabilities in your feature branch should also have a test case to protect them in the future.

```
# NACA0012
naca0012              = TestCase('naca0012')
naca0012.cfg_dir      = "euler/naca0012"
naca0012.cfg_file     = "inv_NACA0012_Roe.cfg"
naca0012.test_iter    = 20
naca0012.test_vals    = [-4.047448, -3.538057, 0.338691, 0.023131] #last 4 columns
naca0012.su2_exec     = "SU2_CFD"
naca0012.timeout      = 1600
naca0012.tol          = 0.00001
test_list.append(naca0012)
```

If the computed values after one of your commits don't match these values, you will get an email with details of the failed cases. Investigate it!

1. Add a new test case to serial_regression.py, parallel_regression.py, etc. Use others as a guide. See NACA 0012 example.

2. Put the config file and any supporting data in the corresponding locations. Travis CI combines the complementary sets.

su2code / SU2

Unwatch 164 | Unstar 378 | Fork 362

Code | Issues 94 | Pull requests 16 | Projects 1 | Insights | Settings

Branch: master — SU2 / TestCases / euler / naca0012 / — Create new file | Upload files | Find file | History

economon Merging develop. — Latest commit 08c5178 on Jun 19

..

inv_NACA0012.cfg	Merging develop.	3 months ago
inv_NACA0012_Roe.cfg	Changed version numbers for v6.1.0.	3 months ago

Lighter weight, more frequently updated files go in code repo.

su2code / TestCases

Unwatch 73 | Unstar 15 | Fork 73

Code | Issues 0 | Pull requests 0 | Projects 0 | Wiki | Insights | Settings

Branch: master — TestCases / euler / naca0012 / — Create new file | Upload files | Find file | History

economon Moved config files only back over into SU2 repo from the TestCases repo. — Latest commit 7b020e6 on Aug 11, 2015

..

mesh_NACA0012_inv.su2	Added all of the mesh files that are < 30 MB	4 years ago

Larger, more static files that support the tests go in the TestCases repo.

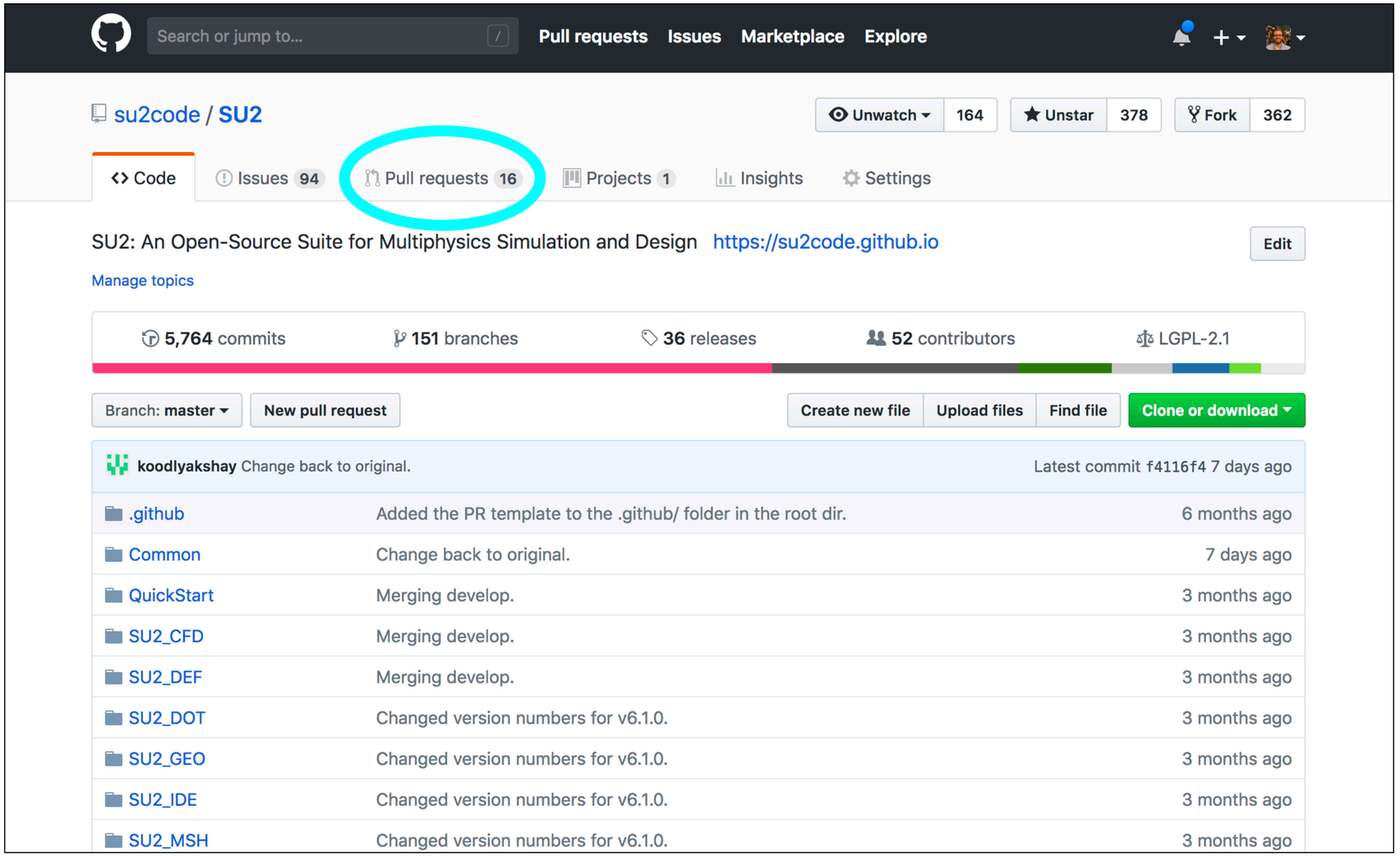
- So, you've finished your awesome feature and the tests are passing. You've even added your own regression test (or two), and you checked that there are no new compiler warnings and the style conforms to the SU2 standard.

- At this point you are wondering, "I would like to contribute my feature to the open source, but how do I do that?"

- To get your work into an official open-source release of SU2, the modifications have to first be staged in the develop branch.

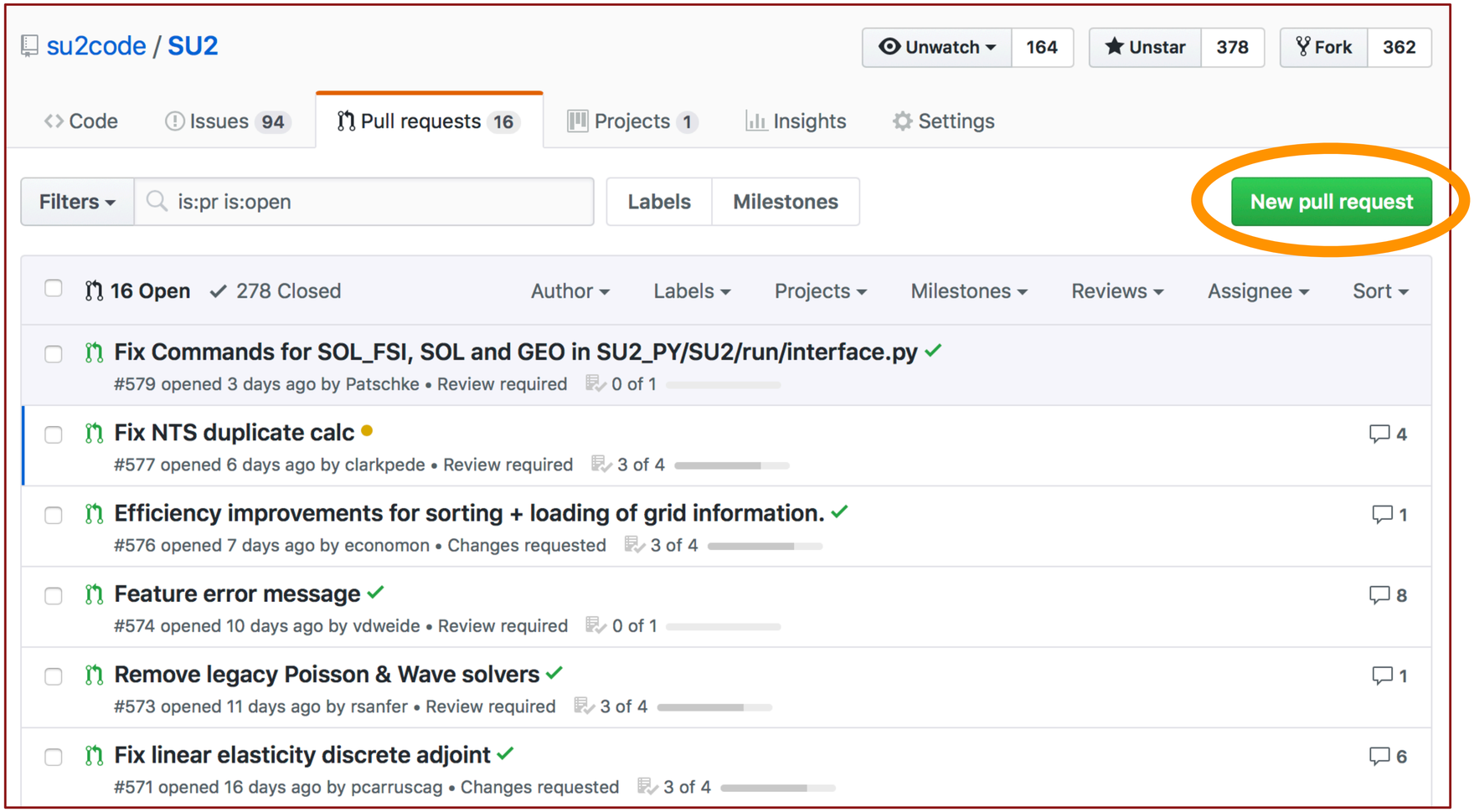
- To do so, we use the standard **Pull Request (PR)** approach.

Git/Branching — Development — Regressions — Pull Request — Release



Once you're ready to contribute, it's PR time.

Git/Branching Development Regressions Pull Request Release

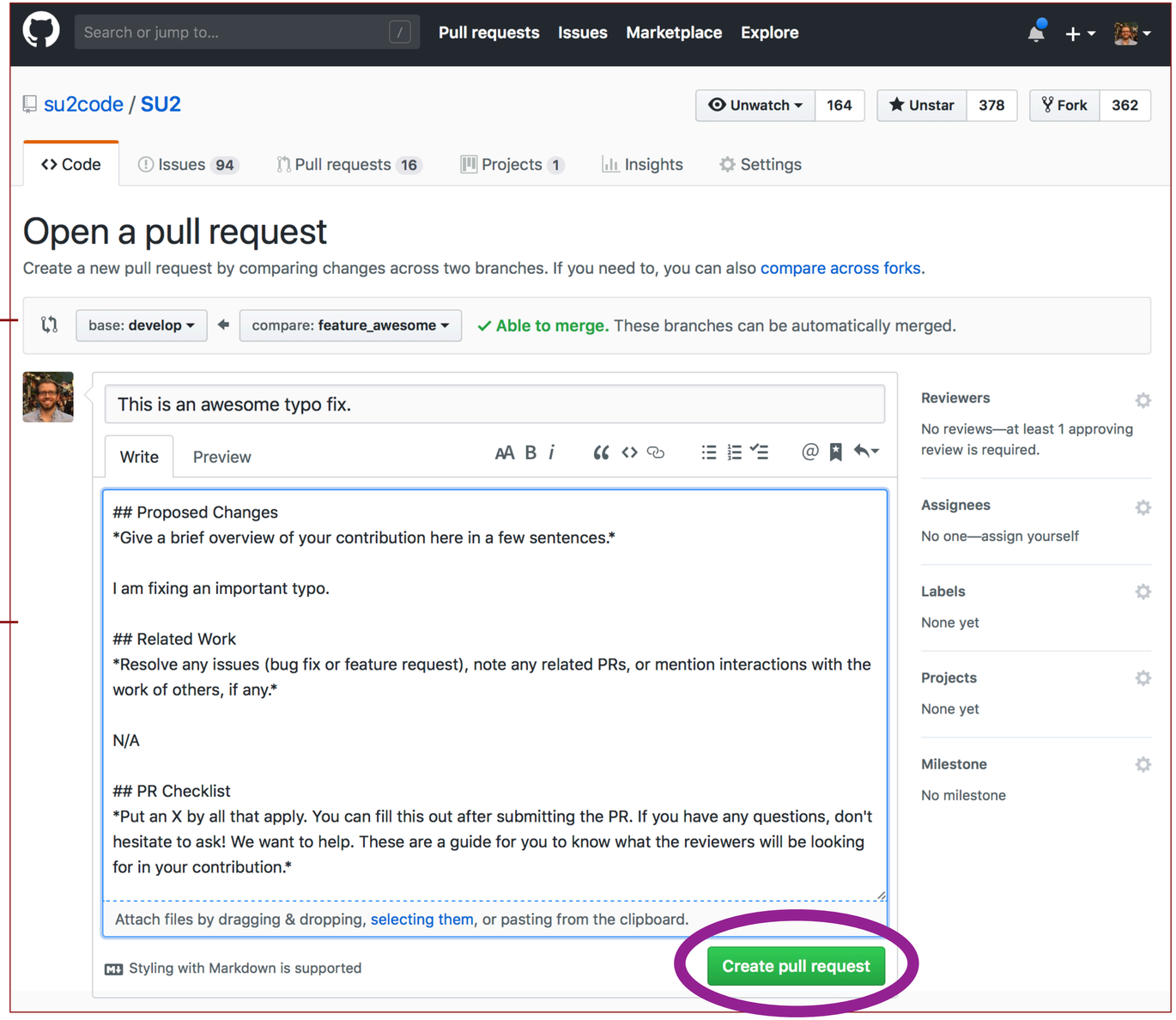


A PR is a request to the project to pull in your contribution. Can be from an internal branch or from an external fork.

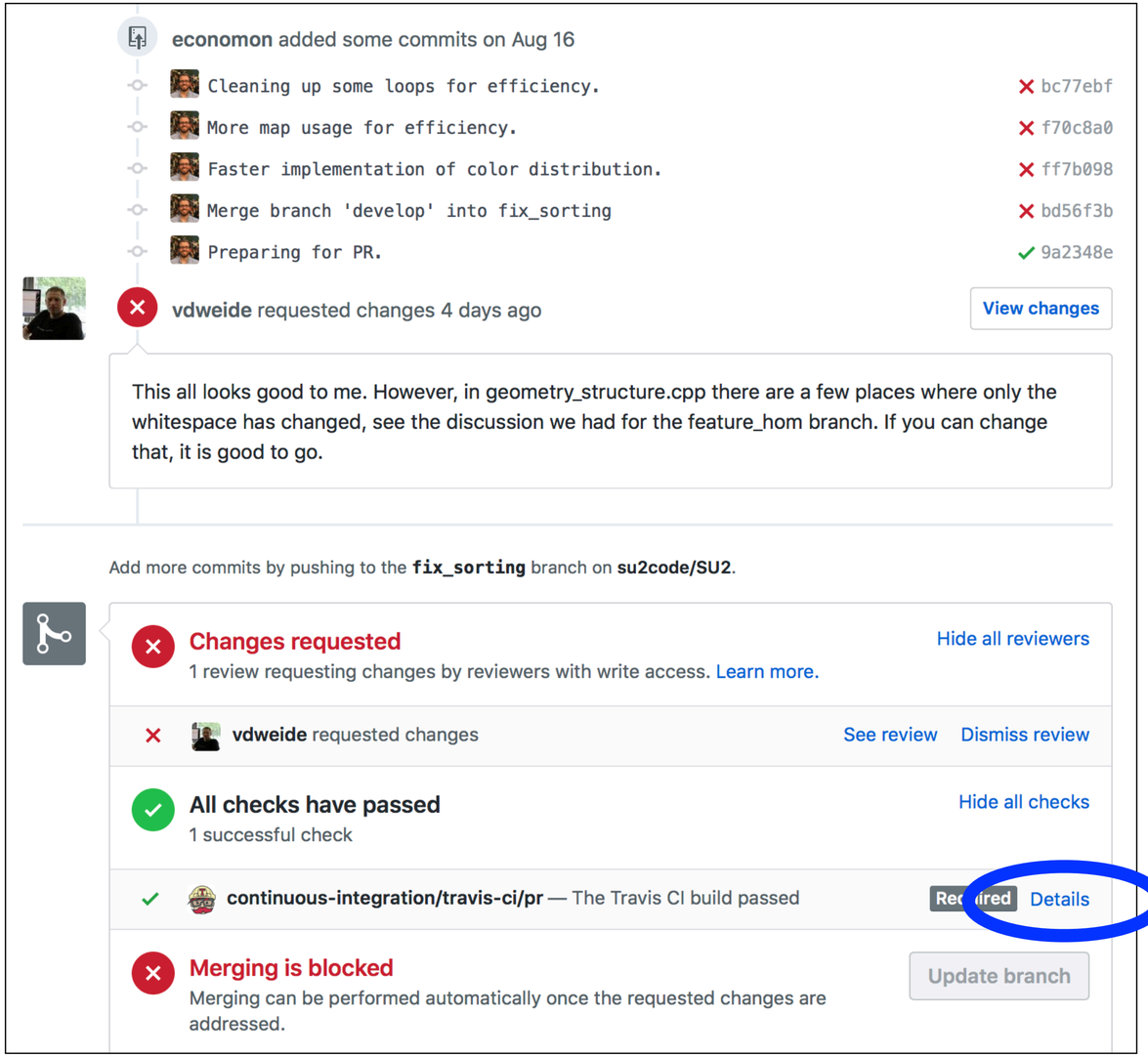
Git/Branching — Development — Regressions — Pull Request — Release

Submit the PR to the develop branch

Fill out the PR template questions that guide you along your way.



Git/Branching Development Regressions Pull Request Release



All regression tests must pass with your code integrated. Travis CI again takes care of this for us. Merging is blocked until passage.

Code is reviewed by fellow developers for content, organization, and style. PR is blocked until at least one approval! Our convention is 2 reviewer approvals.

PRs keep community informed, offer opportunity for discussion, and are a *controlled gate* for quality assurance of contributions.

Details of the tests for all PRs can be found over in Travis CI.

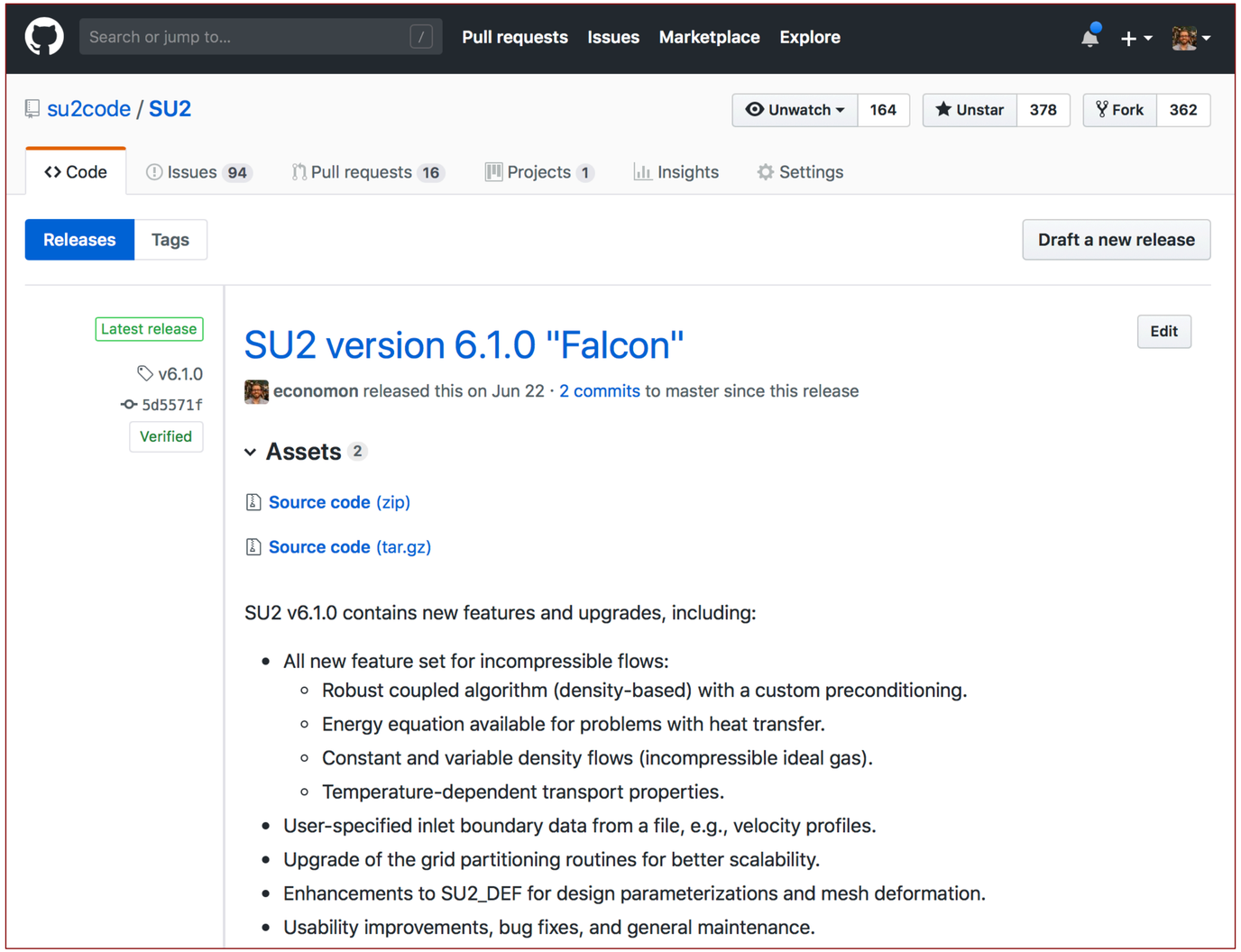
su2code / SU2

build unknown

Current Branches Build History Pull Requests More options

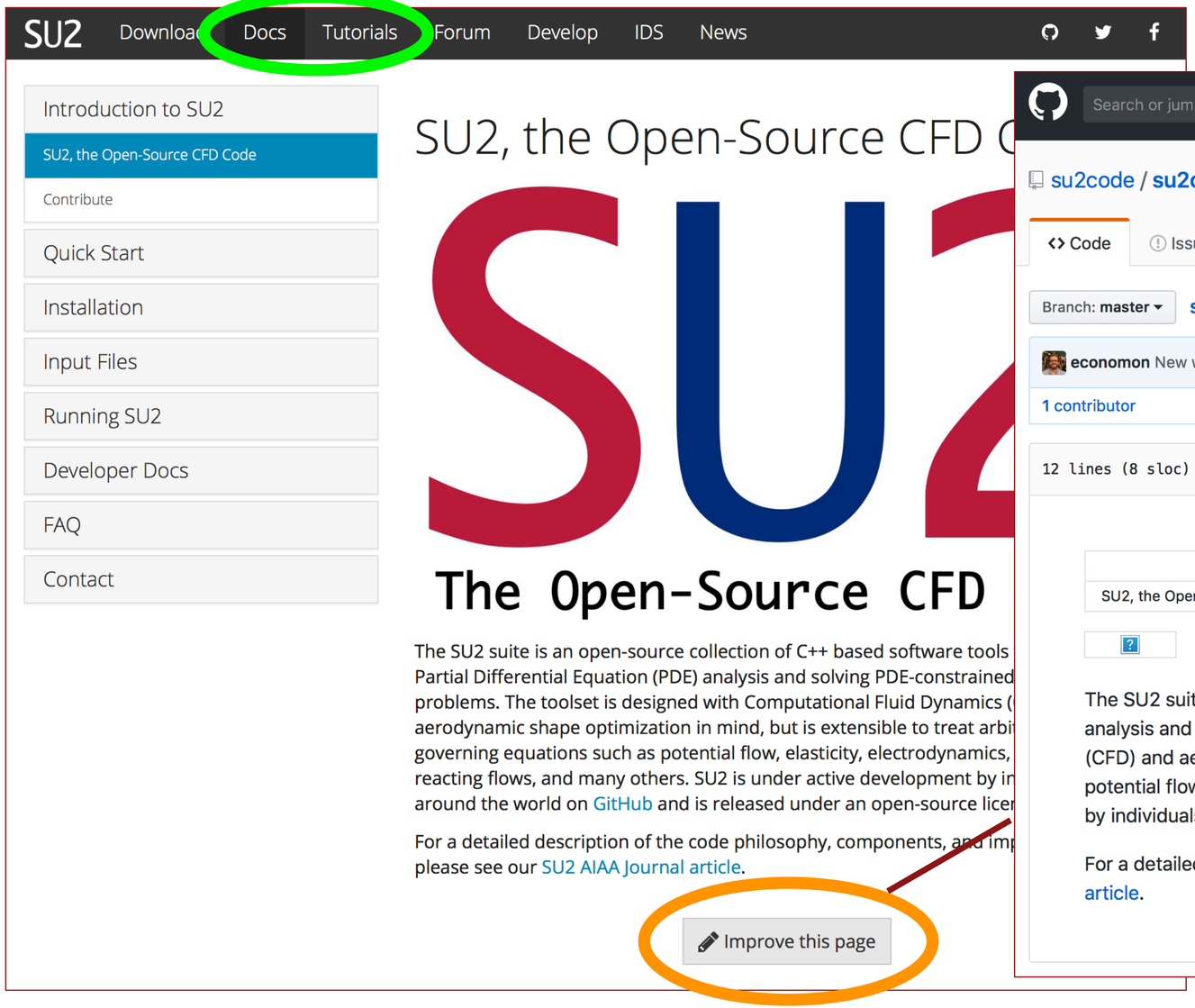
✓ PR #570 Jayant Mukhopadhaya	Feature sst uq	#2342 passed d7e05f9	7 hrs 54 min 5 sec about 17 hours ago
✓ PR #565 vdweide	Feature hom	#2341 passed e82f700	9 hrs 33 min 54 sec a day ago
✓ PR #565 vdweide	Feature hom	#2338 passed e6418bb	9 hrs 35 min 20 sec 2 days ago
✓ PR #579 Patrick	Fix Commands for SOL_FSI, SOL and GEO in SU2_PY/SU2/r	#2335 passed e9f8913	8 hrs 1 min 48 sec 2 days ago
✓ PR #565 vdweide	Feature hom	#2334 passed be211e3	9 hrs 29 min 55 sec 3 days ago
✓ PR #565 vdweide	Feature hom	#2333 passed c37f4d9	9 hrs 30 min 44 sec 3 days ago
✗ PR #570 Jayant Mukhopadhaya	Feature sst uq	#2332 failed 1348d87	8 hrs 4 min 19 sec 3 days ago
✓ PR #565 vdweide	Feature hom	#2331 passed 7029bc1	11 hrs 27 min 48 sec 4 days ago
✓ PR #574 vdweide	Feature error message	#2330 passed 2d4bd6f	8 hrs 8 min 38 sec 4 days ago

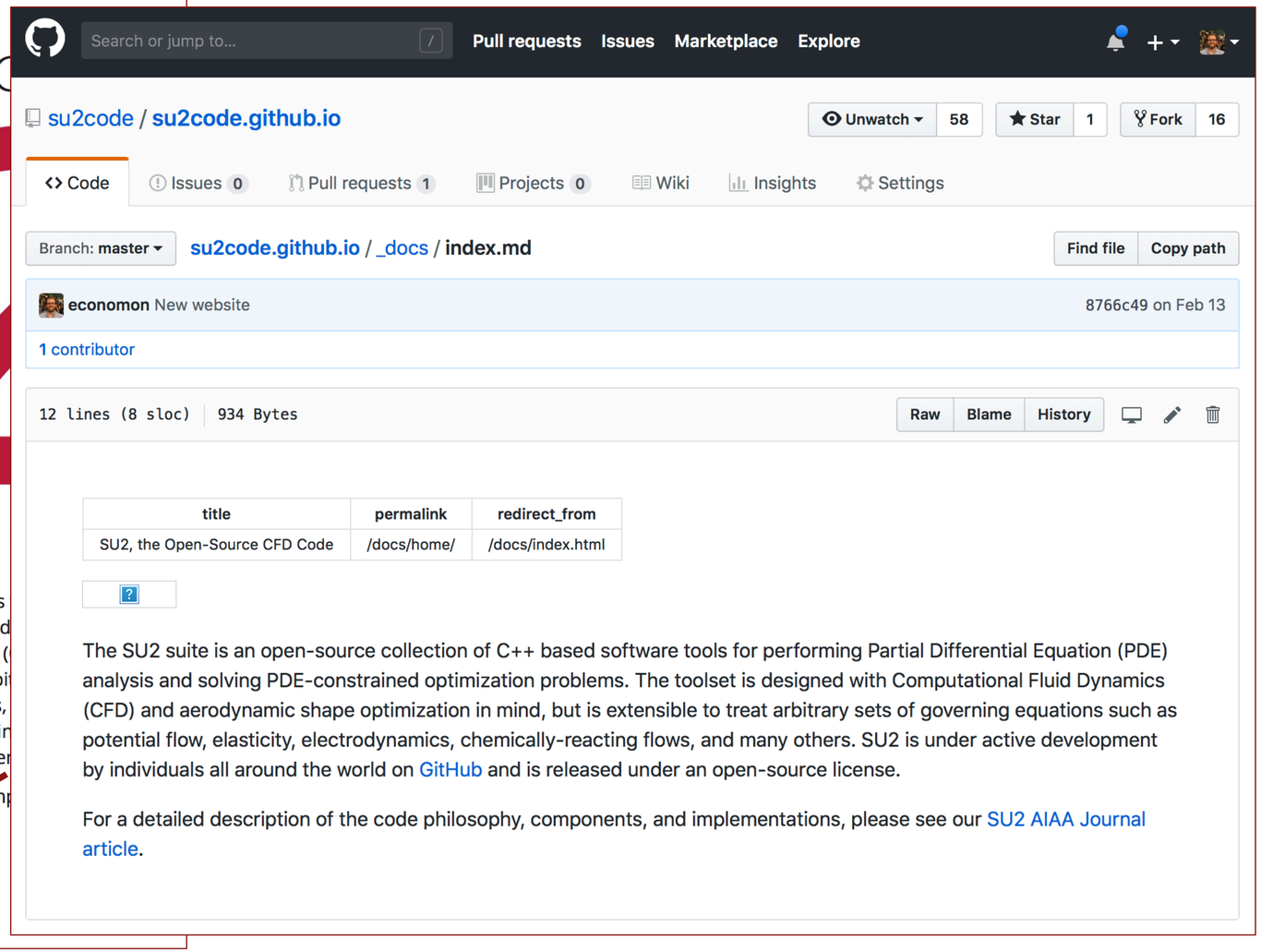
Git/Branching Development Regressions Pull Request Release



Releases: we move develop to master, create tags, binaries, and advertise. Your awesome feature is released!

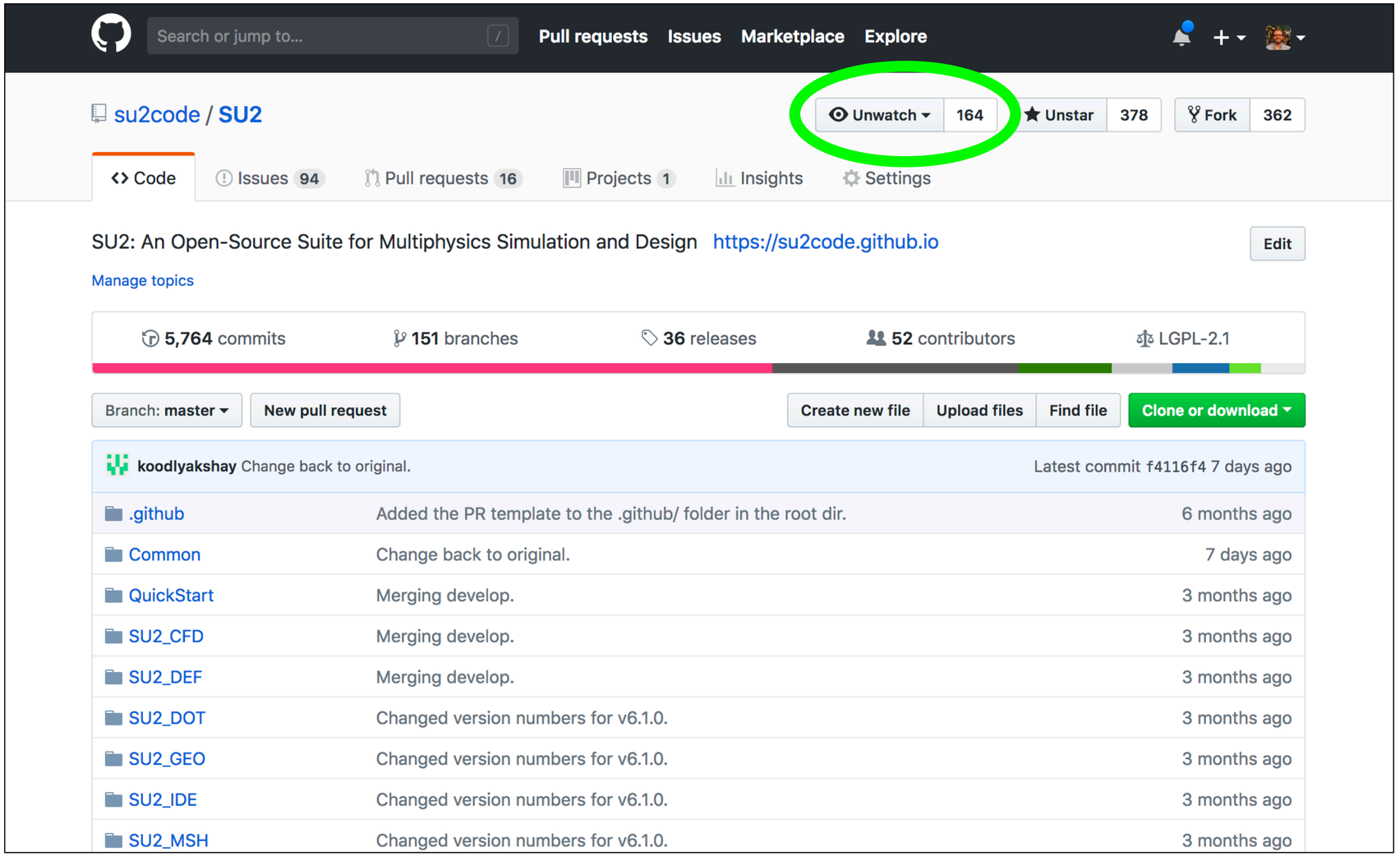
Git/Branching Development Regressions Pull Request Release





Documentation and tutorials are critical for amplifying the impact of your work. Good news: it's the same process to create it.

Git/Branching Development Regressions Pull Request Release



Keep up-to-date via email with all of the activity in the repo by “watching”

SU2 Development Survival Guide

A Best Practice Workflow

1. Clone main repository: $ git clone https://github.com/su2code/SU2.git

2. Create new feature branch (in remote and locally) for your development work. Work on this branch in the repo.

3. Activate the regressions for your branch by changing to your branch name and email in .travis.yml. Use this to guide development and correct any failures along the way that you will be informed of by email.

4. Work on your feature! Please mind white space issues, compiler warnings, and match the SU2 style.

5. If you are working on a single branch for an extended amount of time, merge the remote develop branch into your own branch at regular, frequent intervals. This ensures that, when the time comes, it will be easy to merge your contribution into develop, as you will have solved any conflicts on your side before a PR.

6. Once you feel your feature is finished, submit a PR. Fill out the PR template that is provided for you.

7. Get reviews and engage with the community concerning your contribution. Fix problems in your branch or address any feedback on the message boards. Note that any new commits will appear right there in the open PR and will kick-off the regressions again.

8. Once the reviewers approve and the regressions pass, the community will merge in your work.

9. Celebrate your contribution and proudly introduce yourself as an SU2 developer at your social engagements.

Pretty easy to be a developer, huh?

We have set up safety nets and removed overhead wherever possible.

So, try crazy ideas in your branches. Don’t be afraid to make big changes that push the boundaries of the code. The community and infrastructure will be there to help you. This is how we make progress.

3rd Annual SU2 Developers Meeting

September 16th-18th, 2018

University of Strathclyde, Scottish Universities Insight Institute (SUII)

Glasgow, Scotland, UK

SU2

The Open-Source CFD Code

Meeting Agenda for Sunday September 16th

0900 – 0915: Welcome & Agenda

0915 – 1045: Introduction to developing in SU2: *Covering high level class design, how to modify the code, working with GitHub (branching, PRs, regressions), etc.*

1045 – 1615: Hack session: *Separate groups working on various problems (lunch and snacks/coffee offered in the room while working)*

1615 – 1700: Wrap-up Presentations: *Two-slide presentations on major progress for the day, including discussion*

1730 – open: Social at "The Counting House", *2 St Vincent Place, G1 2DH*

Meeting Agenda for Monday September 17th

0800 – 0830: Welcome & Year in review, *T. Economon (Bosch), J.J. Alonso (Stanford)*

0830 – 0900: SU2-NEMO - Thermochemistry and high-Mach aerothermodynamics, *M. Fossati (U. of Strathclyde), T. Magin, J.B. Scoggins, M. Pini, P. Colonna, R. Sanchez, T. Economon, D. Mayer, N. Beishuizen, C. Garbacz-Gomes, W.T. Meier, J.J. Alonso, T. van der Stelt*

0900 – 0930: Toward optimization for reactive flows in SU2, *N. Beishuizen (Bosch), D. Mayer, T. Economon*

0930 – 1000: Conjugate heat transfer problems and computing coupled discrete adjoints using AD, *O. Burghardt (TU Kaiserslautern), T. Albring, N. Gauger*

1000 – 1030: Coffee break

1030 – 1100: Physics-based RANS model-form UQ in SU2, *J. Mukhopadhaya (Stanford), A. Mishra, J.J. Alonso, G. Iaccarino*

1100 – 1130: Aeroacoustics prediction and optimization capabilities in SU2, *B. Zhou (NIA/NASA-Langley), T. Albring, N. Gauger, C. Ilario, T. Economon, J.J. Alonso, L. V. Lopes, H. Yao, S. Peng, L. Davidson*

1130 – 1200: Higher-order SU2: DG-FEM solver and WENO-FV solver with LES/ILES/WMLES applications, *E. van der Weide (U. of Twente), J.J. Alonso, D. Drikakis, K. Singh, P. Urbanczik, E. Molina, J.H. Choi*

1200 – 1300: Lunch

1300 – 1330: Unsteady optimization with SU2: application to turbomachinery design, *A. Rubino (TU Delft), M. Pini, N. Anand, P. Colonna*

1330 – 1400: Preliminary results on rotor-fuselage aerodynamics using SU2: status and challenges, *M. Morelli (Politecnico di Milano), G. Gori, A. Guardone*

1400 – 1430: Anisotropic mesh adaptation with the INRIA AMG library, *A. Loseille (INRIA), V. Menier, B. Munguia, J.J. Alonso*

1430 – 1500: Coffee break

1500 – 1530: Simulation and adjoint-based design for variable density incompressible flows with heat transfer, *T. Economon (Bosch)*

1530 – 1600: Implementation of pressure-based Navier-Stokes for wind energy applications, *A. Ravishankara (ECN part of TNO), H. Ozdemir, E. van der Weide*

1600 – 1630: SU2-IDS: International Developers Society, *T. Albring, R. Sanchez (TU Kaiserslautern), T. Economon, F. Palacios*

1630 – 1700: Wrap up, *J.J. Alonso (Stanford)*

In order to participate (in-person or virtually), please register for the meeting by following the link on the SU2 home page (https://su2code.github.io).

*Please note that all stated times are British Summer Time (BST). **The presenter author is underlined

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