Git Workflows

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Better Scientific Software Tutorial, ISS, March 2021

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- **The requested citation the overall tutorial is: David E. Bernholdt, Anshu Dubey, Rinku K. Gupta, and David M. Rogers, Better Scientific Software tutorial, in Improving Scientific Software conference, online, 2021. DOI: 10.6084/m9.figshare.14256257**
- Individual modules may be cited as *Speaker, Module Title*, in Better Scientific Software tutorial…

Acknowledgements

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Content

- Brief explanation of Version Control with Git
- Git Workflow Mechanisms for Collaboration
  - Branches
  - Pull Requests
  - Forks
- Exposure to workflows of different complexity
- What to think about when evaluating different workflows
- Extra: Heat Equation Example Workflow

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Goal

Development teams would like to use version control to collaborate productively and ensure correct code.

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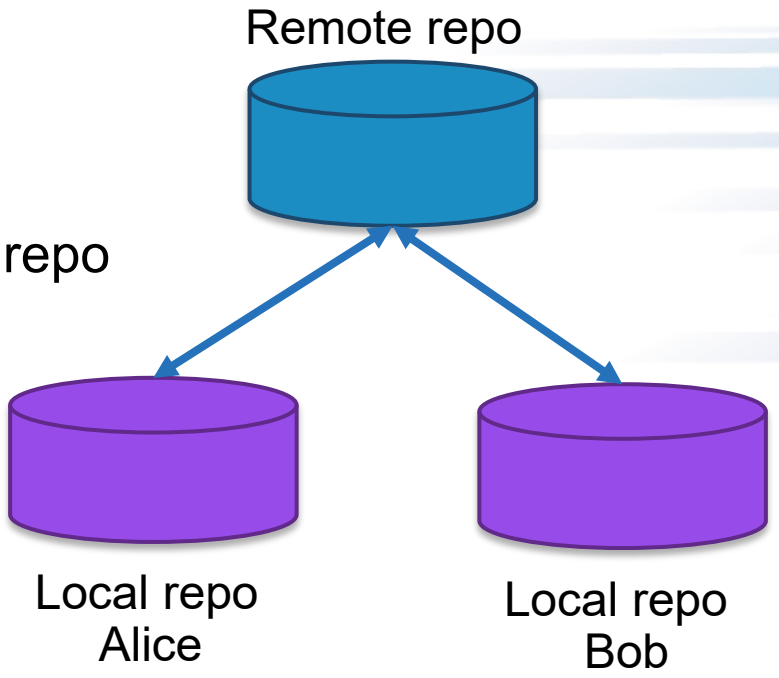
First Workflow

This process of collaborating *via* Git is called the **Centralized Workflow**

- See Atlassian/BitBucket for more information
- “Simple” to learn and “easy” to use
- Leverages local vs. remote repo dimension
  - Integration in local repo when local repos interact with remote repo
- What if you have many team members?
- What if developers only push once a month?
  - Lengthy development efforts without integrating
  - Occasional contributors
- What if team members works on different parts of the code?
- Working directly on master



Git Workflow Mechanisms for Collaboration

- Branches
  - Enable separate development for features or fixes on the same repo
  - Enables different types of Workflows
- Pull Requests
  - Enables code review and testing before merge
- Forks
  - Enables outside contributors that have read access only
  - Controls on original repo remains with the team

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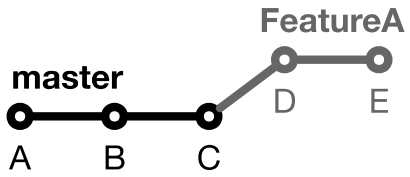
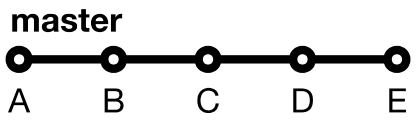
Branches

Branches are independent lines of development

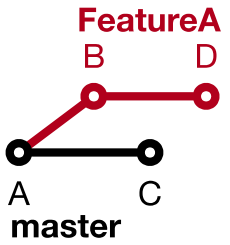
- Use branches to protect master branch
- Feature branches
  - Organize a new feature as a sequence of related commits in a branch
- Branches are usually combined or **merged**
- Develop on a branch, test on the branch, and merge into master
- Integration occurs at merge commits



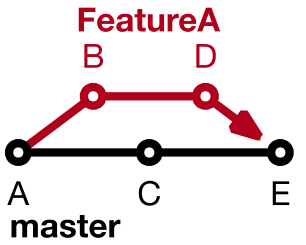
Fast-Forward



No Merge



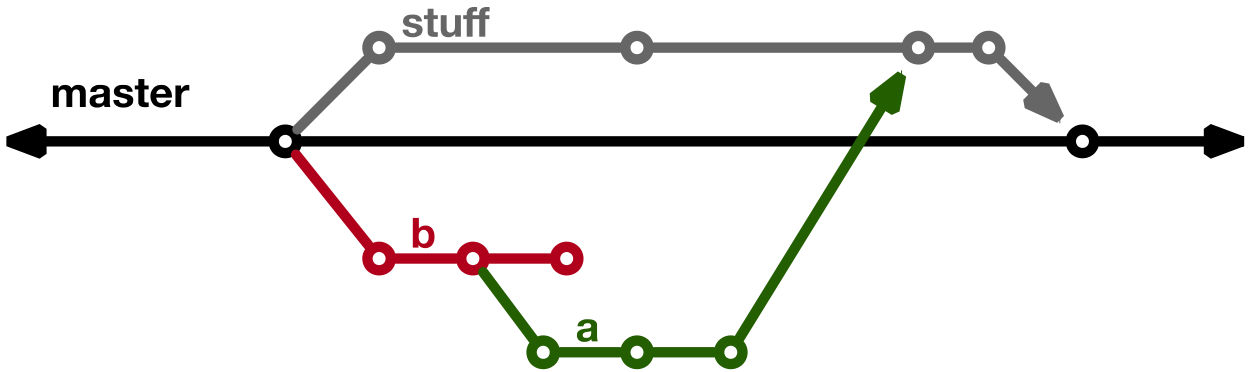
Divergence



Merge Commit

Control Project Branch Complexity

- Workflow policy is needed
  - Project supported branches and workflows should not be unnecessarily complex
  - Individuals and sub-teams can leverage more complex models when advantageous
  - Descriptive names or linked to issue tracking system
  - Where do branches start and end?



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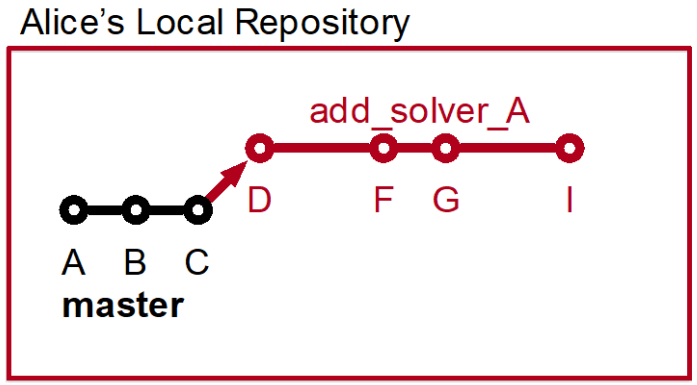
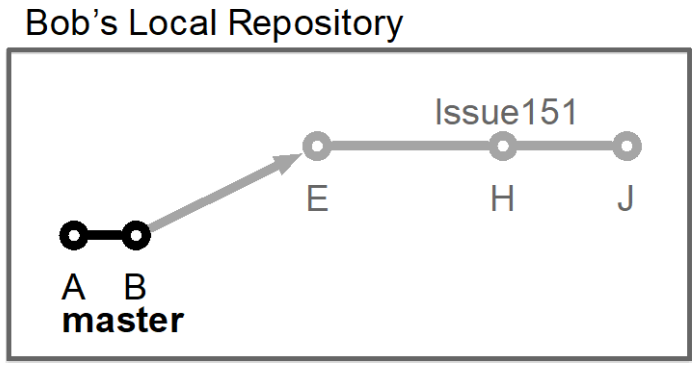
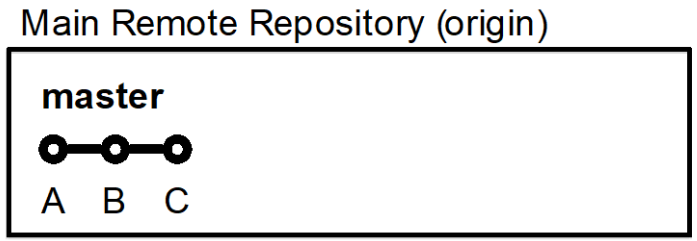
Feature Branches

Extend Centralized Workflow

- Remote repo has commits A & B
- Bob pulls remote to synchronize local repo to remote
- Bob creates local feature branch based on commit B
- Commit C pushed to remote repo
- Alice pulls remote to synchronize local repo to remote
- Alice creates local feature branch based on commit C
- Both develop independently on local feature branches



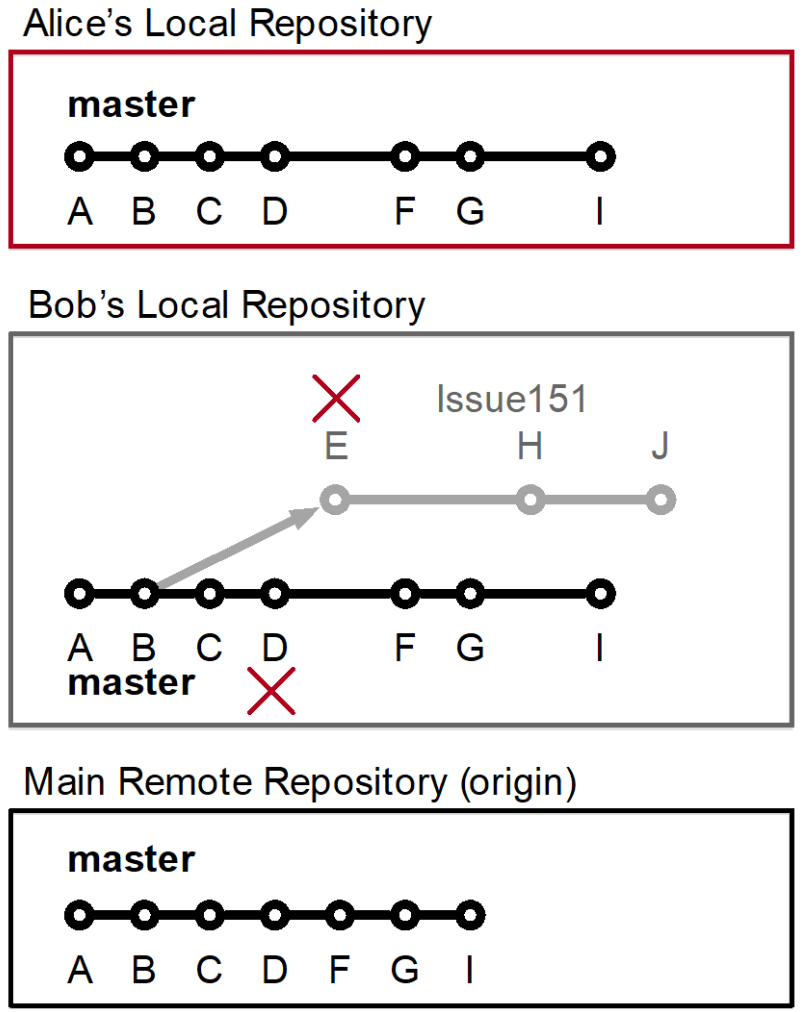




Feature Branch Divergence

Alice integrates first without issue

- Alice does fast-forward merge to local master
- Alice deletes local feature branch
- Alice pushes master to remote
- Meanwhile, Bob pulls master from remote and finds Alice's changes
- Merge conflict between commits D and E

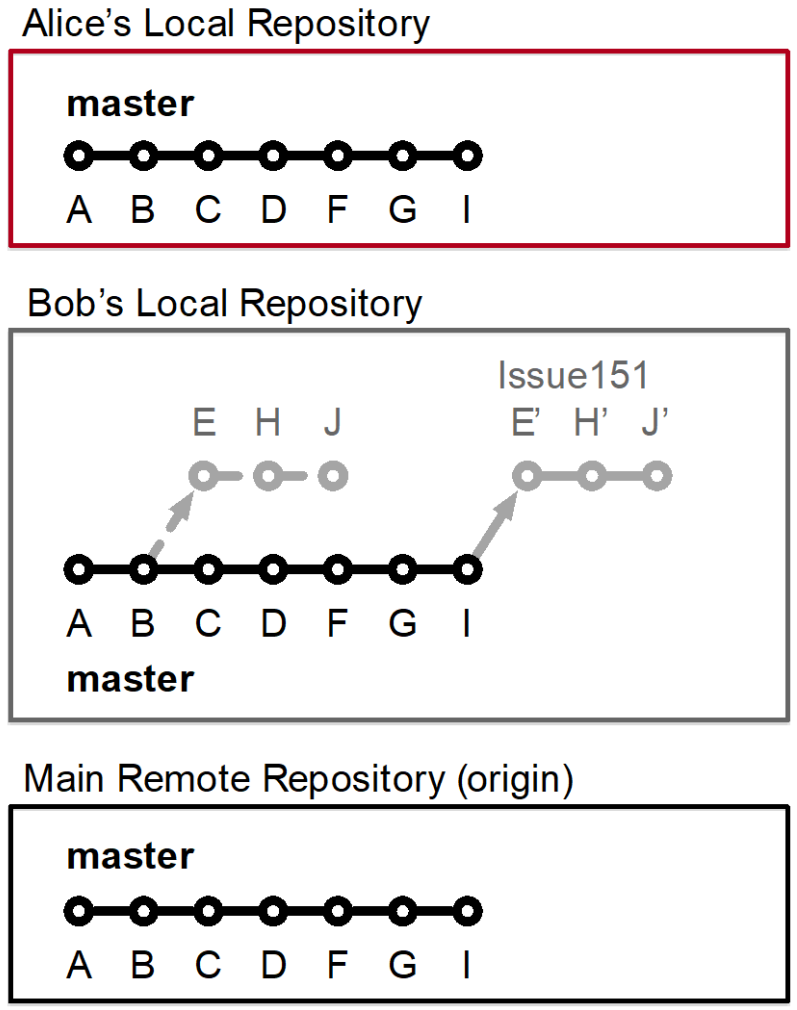


Feature Race Condition

Integration occurs on Bob's local repo

- Bob laments not having fast-forward merge
- Bob **rebases** local feature branch to latest commit on master
  - E based off of commit B
  - E' based off of Alice's commit I
  - E' is E integrated with commits C, D, F, G, I
- Merge conflict resolved by Bob & Alice on Bob's local branch when converting commit E into E'
- Can test on feature branch and merge easily and cleanly

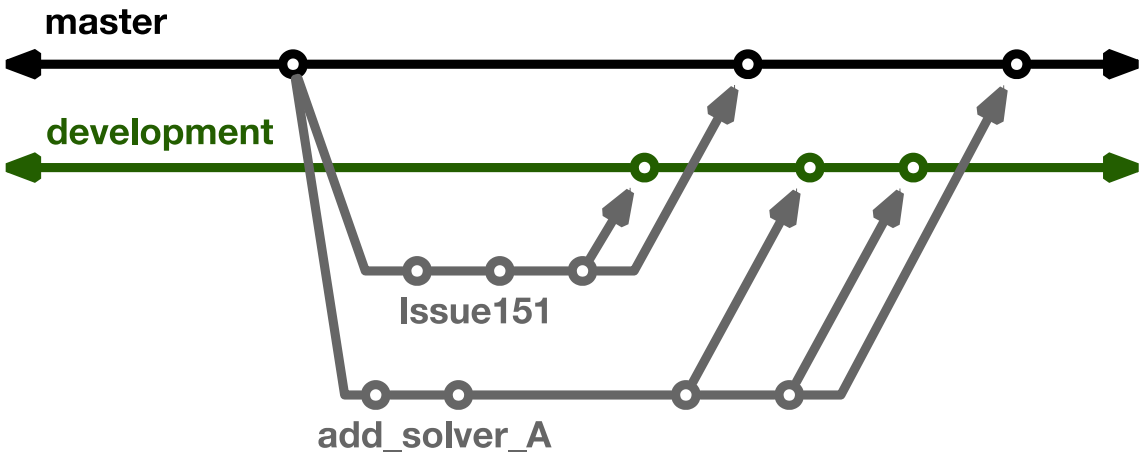
- See Atlassian/BitBucket for a richer Feature Branch Workflow



More Branches

Branches with infinite lifetime

- Base off of master branch
- Exist in all copies of a repository
- Each provides a distinct **environment**
  - Development vs. pre-production



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Pull Requests

- Review and testing before merge
  - Alerts others about changes in branch before merge
  - Discussions ensue with possible follow up commits
  - Can request reviewer
- Set policies for merge

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GitHub Forks

- A “fork” of a repository is a complete copy of another repository, inside a different GitHub account.
  - Forking requires read access to the main (often referred to as “upstream”) repository
    - Forks of public repositories are public
    - Other users can be granted write access to your fork
    - You cannot fork a fork
  - Does not copy issues or pull requests
  - Use branches within your fork (do not modify master)
  - A pull request (GitLab uses “merge request”) can be used to suggest changes to the upstream repository
    - Added benefit: pull requests from forks prevent huge numbers of branches on the upstream repository

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Git Workflow Models of Different complexity

- Git Flow
- Github Flow
- Gitlab Flow
- Trilionos Workflow

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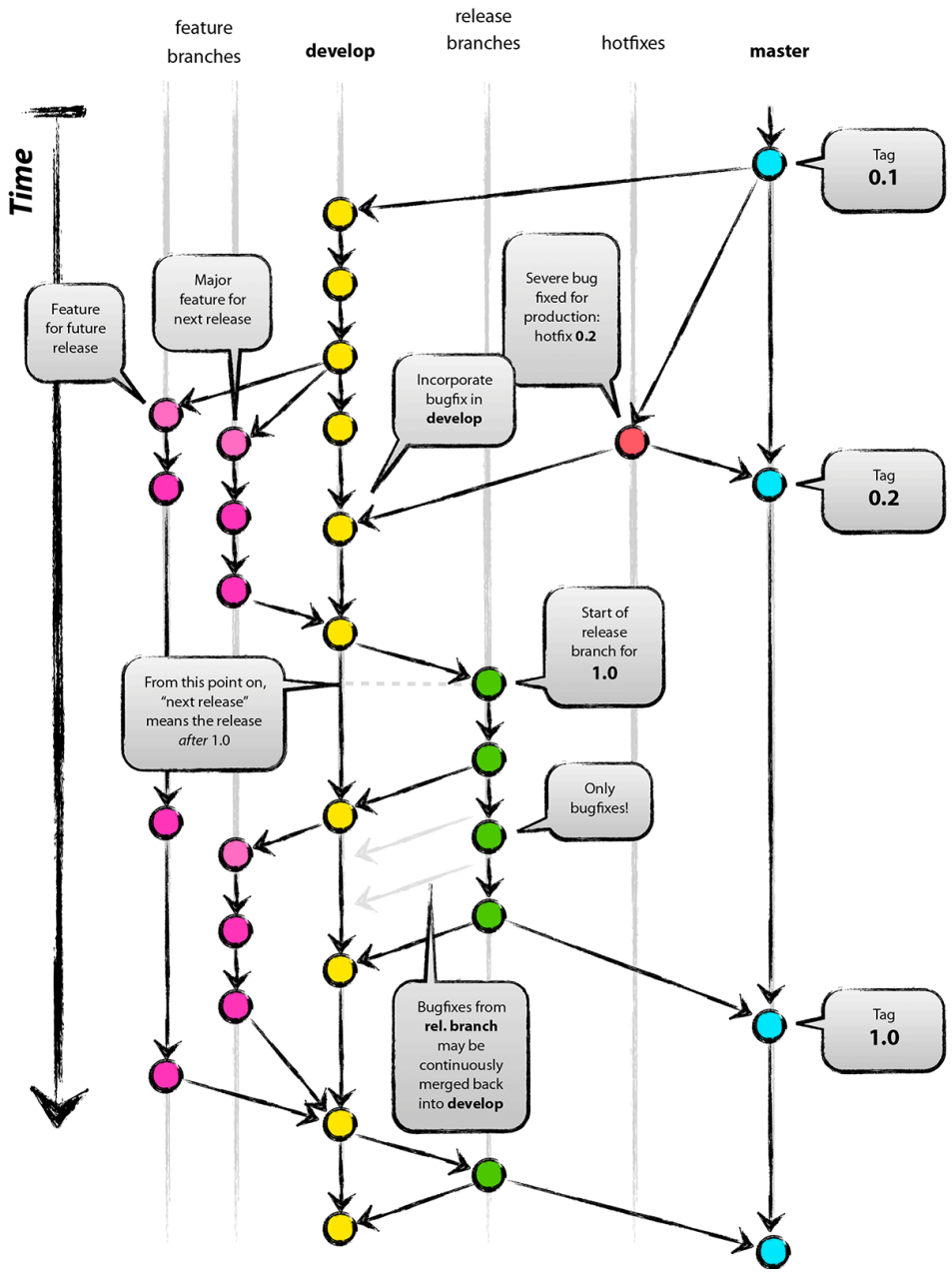
Git Flow



- Full-featured workflow
- Increased complexity
- Designed for SW with official releases
- Feature branches based off of develop
- Git extensions to enforce policy
- How are develop and master synchronized?
- Where do merge conflicts occur and how are they resolved?

Author: Vincent Driessen
Original Blog: https://nvie.com/posts/a-successful-git-branching-model/
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GitHub Flow

http://scottchacon.com/2011/08/31/github-flow.html

- Published as viable alternative to Git Flow
- No structured release schedule
- Continuous deployment & continuous integration allows for simpler workflow

Main Ideas

1. All commits in master are **deployable**
2. Base feature branches off of master
3. Push local repository to remote constantly
4. Open Pull Requests early to start dialogue
5. Merge into master after Pull Request review

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GitLab Flow

https://docs.gitlab.com/ee/workflow/gitlab_flow.html

- Published as viable alternative to Git Flow & GitHub Flow
- Semi-structured release schedule
- Workflow that simplifies difficulties and common failures in synchronizing infinite lifetime branches

Main Ideas

- Master branch is staging area
- Mature code in master flows downstream into pre-production & production infinite lifetime branches
- Allow for release branches with downstream flow
  - Fixes made upstream & merged into master.
  - Fixes cherry picked into release branch

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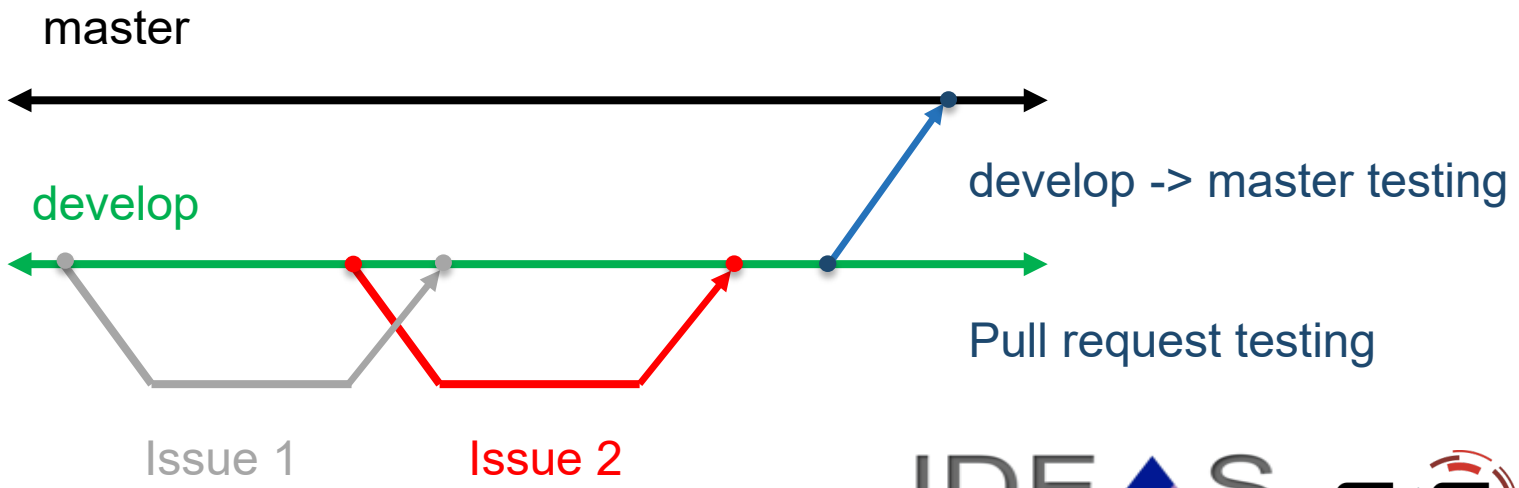
Current Trilinos Workflow

Test-driven workflow

- Feature branches start and end with develop
- All changes to develop must come from GitHub pull requests
- Feature branches are merged into develop only after passing pull request test suite
- Change sets from develop are tested daily for integration into master

Workflow designed so that

- All commits in master are in develop
- Merge conflicts exposed when integrating into develop
- Merge conflicts never occur when promoting to master



Considerations for Choosing a Git Workflow

Want to establish a clear set of polices that

- results in correct code on a particular branch (usually master),
- ensures that a team can develop in parallel and communicate well,
- minimizes difficulties associated with parallel and distributed work, and
- minimizes overhead associated with learning, following, and enforcing policies.

Adopt what is good for your team

- Consider team culture and project challenges
- Assess what is and isn't feasible/acceptable
- Start with simplest and add complexity where and when necessary

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Agenda

Time (MDT)	Module	Topic	Speaker
1:00pm-1:05pm	00	Introduction	David E. Bernholdt, ORNL
1:05pm-1:15pm	01	Motivation and Overview of Best Practices in HPC Software Development	David E. Bernholdt, ORNL
1:15pm-1:45pm	02	Agile Methodologies	Rinku K. Gupta, ANL
1:45pm-2:00pm	03	Git Workflows	Rinku K. Gupta, ANL
2:00pm-2:20pm	04	Software Testing 1	David M. Rogers, ORNL
2:20pm-2:40pm		*Break (optional Q&A)*	*All*
2:40pm-3:00pm	05	Software Design	Anshu Dubey, ANL
3:00pm-3:15pm	06	Software Testing 2	David M. Rogers
3:15pm-3:40pm	07	Refactoring	Anshu Dubey, ANL
3:40pm-3:55pm	08	Reproducibility	David E. Bernholdt, ORNL
3:55pm-4:00pm	09	Summary	David E. Bernholdt, ORNL

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Extra: Demo for Heat Equation Example Workflow

- Fork repository (once)
- Clone the fork (once)
- Create and checkout branch
  - Base branch on current development or other appropriate version for each feature
- Modify and commit code
- Push change to fork
- Issue pull request to upstream repository
- Review pull request
- CI testing (covered in upcoming module)

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Git Workflow for the Heat Equation Example

- Developers
  - Work on feature branches in their forks
    - Using forks requires contributors to have only read-access to primary repository
  - Issue pull requests for changes
    - Natural opportunity to review and test all changes

- Pull requests
  - Are reviewed by at least one developer (not the author)
  - Undergo CI testing prior to merging

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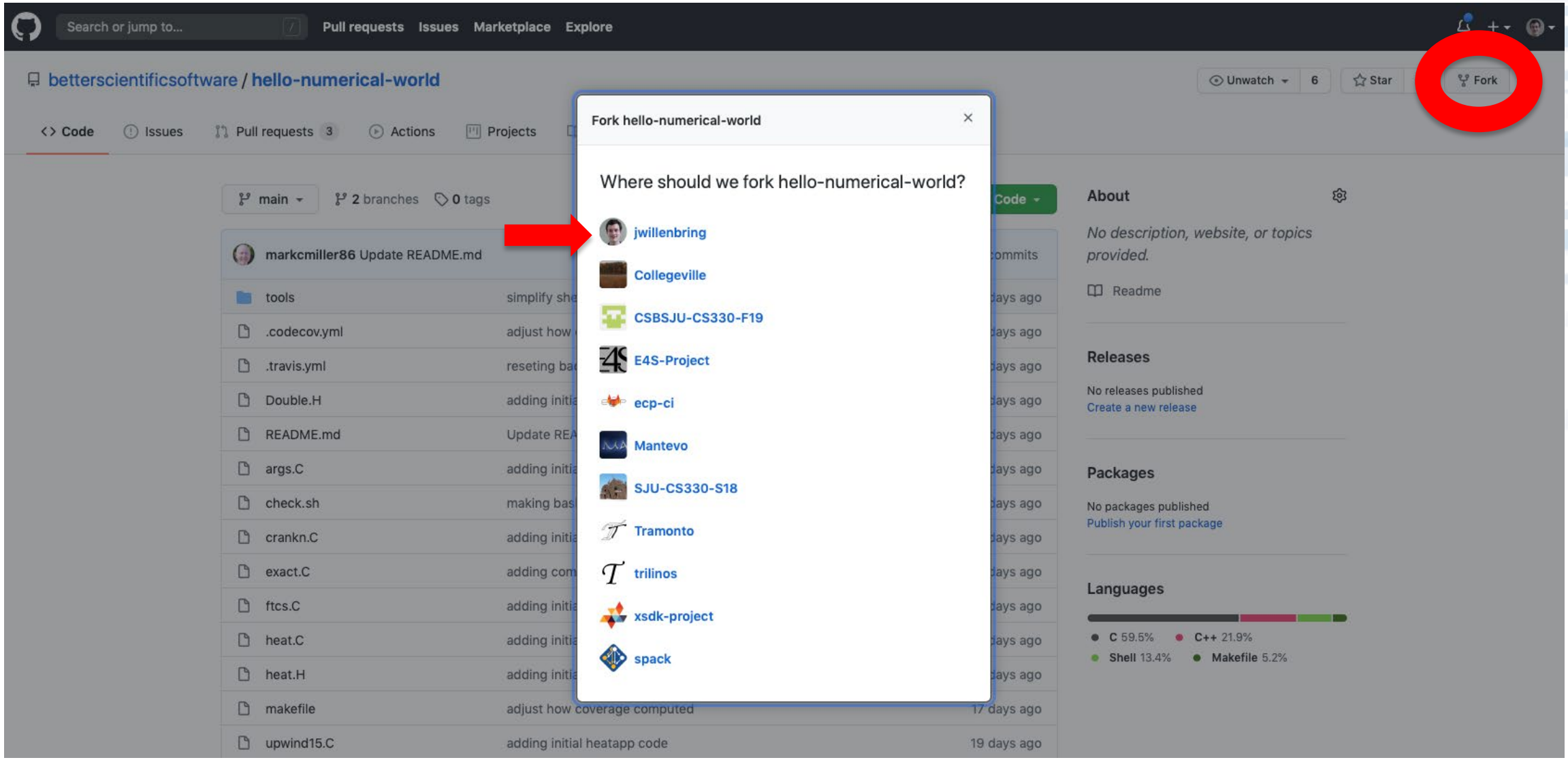
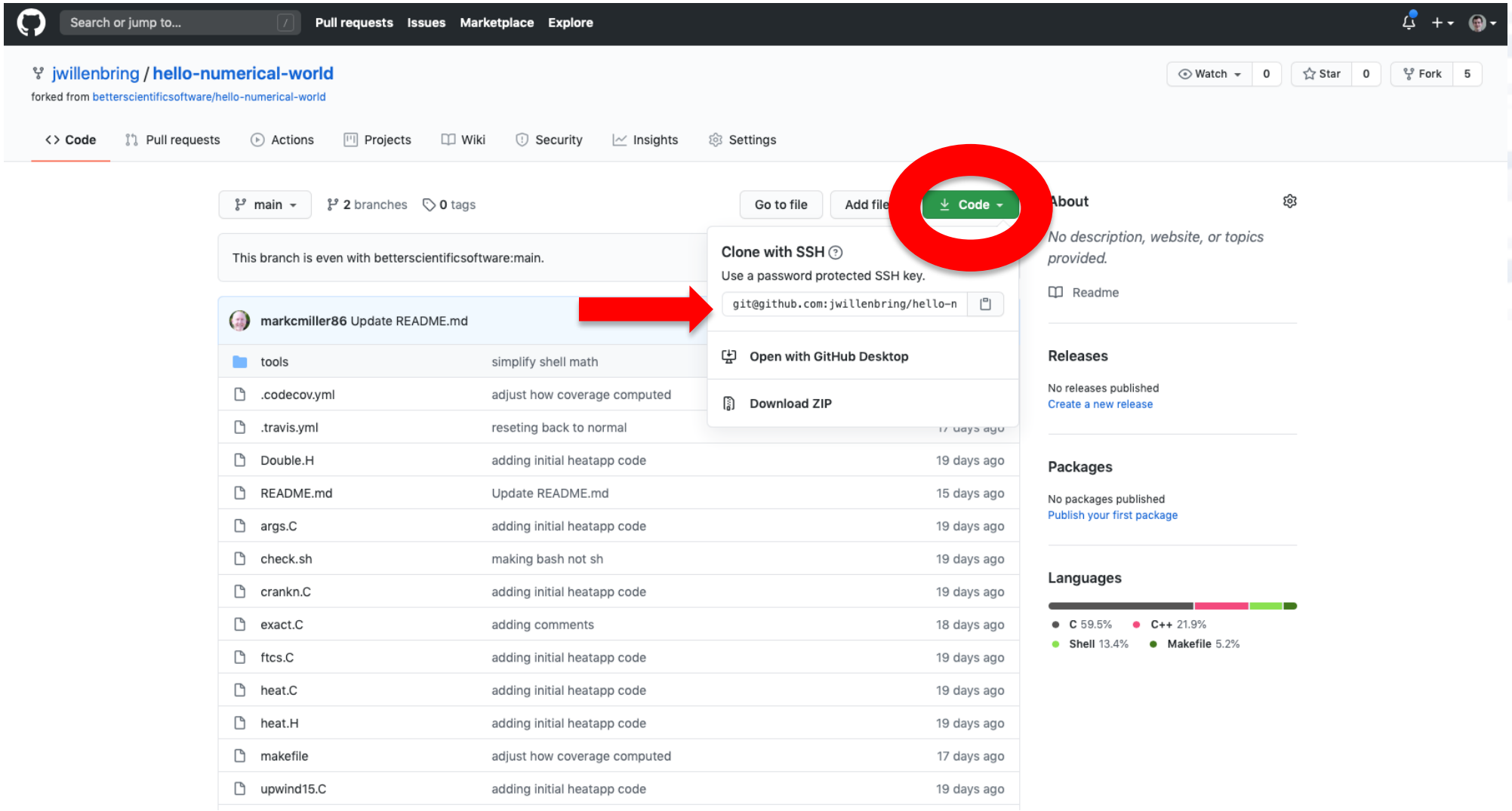
Fork the Repository



Find the Path to Clone



Clone the fork; Create and Checkout a New Branch

```
s988335:repos jmwille$ git clone git@github.com:jwillenbring/hello-numerical-world.git
Cloning into 'hello-numerical-world'...
Enter passphrase for key '/Users/jmwille/.ssh/id_rsa':
remote: Enumerating objects: 102, done.
remote: Counting objects: 100% (102/102), done.
remote: Compressing objects: 100% (52/52), done.
remote: Total 102 (delta 54), reused 94 (delta 50), pack-reused 0
Receiving objects: 100% (102/102), 21.69 KiB | 120.00 KiB/s, done.
Resolving deltas: 100% (54/54), done.
s988335:repos jmwille$
```

```
s988335:repos jmwille$ cd hello-numerical-world/
s988335:hello-numerical-world jmwille$ git checkout -b issue-1000
Switched to a new branch 'issue-1000'
s988335:hello-numerical-world jmwille$
```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Modify and Commit Code

```
s988335:hello-numerical-world jmwille$ vi README.md
s988335:hello-numerical-world jmwille$ git diff
diff --git a/README.md b/README.md
index 3cd1a3c..b44c57e 100644
--- a/README.md
+++ b/README.md
@@ -22,7 +22,7 @@ is known as the _Diffusion Equation_ and also the [_Heat Equation_](https://en.w

 ### Simplifying Assumptions

-To make the problem tractable for this lesson, we make some simplifying assumptions...
+To make the problem tractable for this lesson, we make some simplifying assumptions:

 1. The thermal diffusivity, ![](http://latex.codecogs.com/gif.latex?%5Calpha),
    is constant for all _space_ and _time_.
s988335:hello-numerical-world jmwille$
```

```
s988335:hello-numerical-world jmwille$ git add README.md
s988335:hello-numerical-world jmwille$ git commit -m "replaced ... with :"
[issue-1000 1c3a901] replaced ... with :
 1 file changed, 1 insertion(+), 1 deletion(-)
s988335:hello-numerical-world jmwille$
```


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Push Change to Fork

```
s988335:hello-numerical-world jmwille$ git remote -vv
origin  git@github.com:jwillenbring/hello-numerical-world.git (fetch)
origin  git@github.com:jwillenbring/hello-numerical-world.git (push)
s988335:hello-numerical-world jmwille$ git branch
* issue-1000
  main
s988335:hello-numerical-world jmwille$ git push origin issue-1000
Enter passphrase for key '/Users/jmwille/.ssh/id_rsa':
Enumerating objects: 5, done.
Counting objects: 100% (5/5), done.
Delta compression using up to 4 threads
Compressing objects: 100% (3/3), done.
Writing objects: 100% (3/3), 310 bytes | 310.00 KiB/s, done.
Total 3 (delta 2), reused 0 (delta 0)
remote: Resolving deltas: 100% (2/2), completed with 2 local objects.
remote:
remote: Create a pull request for 'issue-1000' on GitHub by visiting:
remote:      https://github.com/jwillenbring/hello-numerical-world/pull/new/issue-1000
remote:
To github.com:jwillenbring/hello-numerical-world.git
 * [new branch]      issue-1000 -> issue-1000
s988335:hello-numerical-world jmwille$
```


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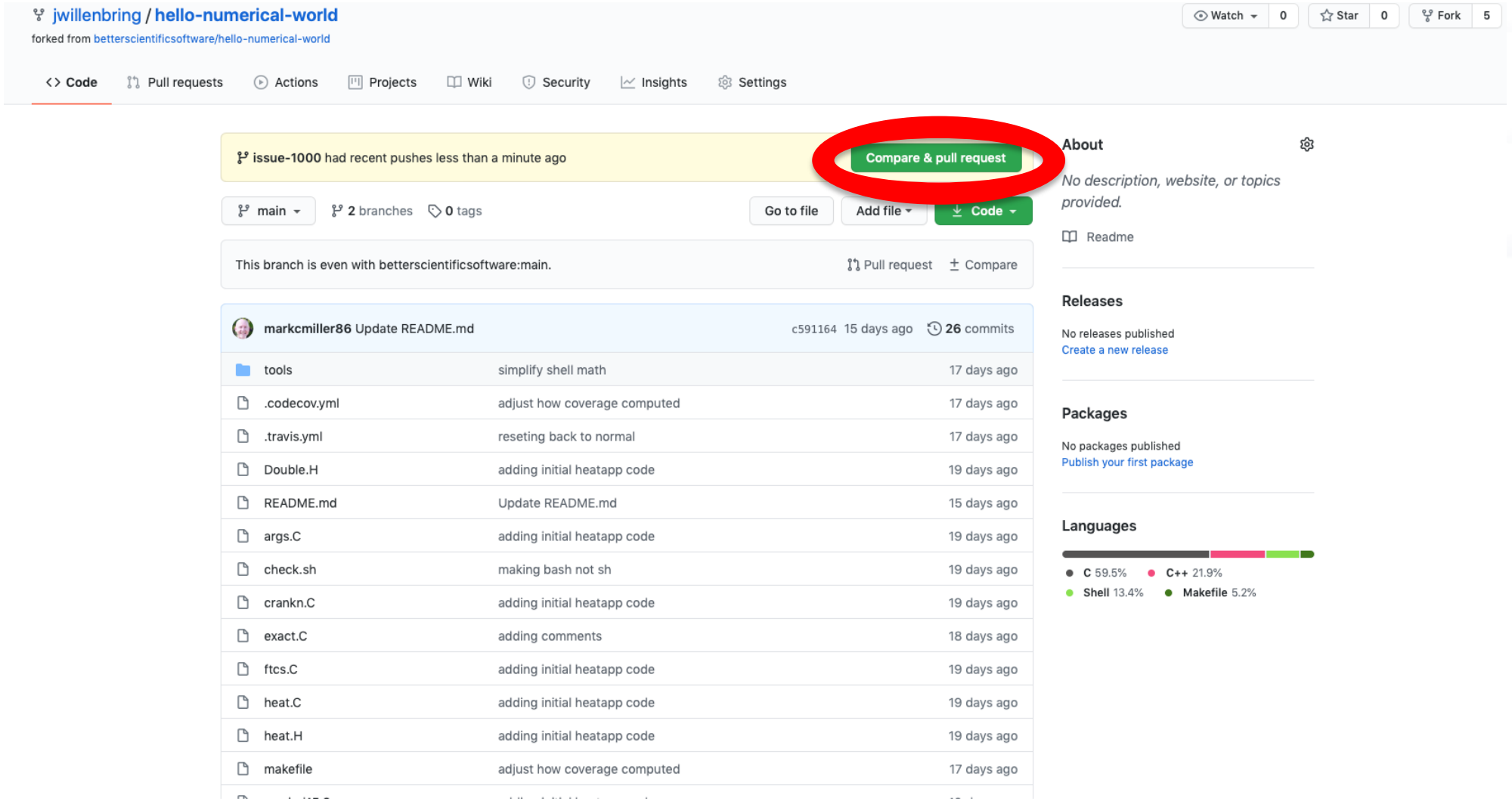
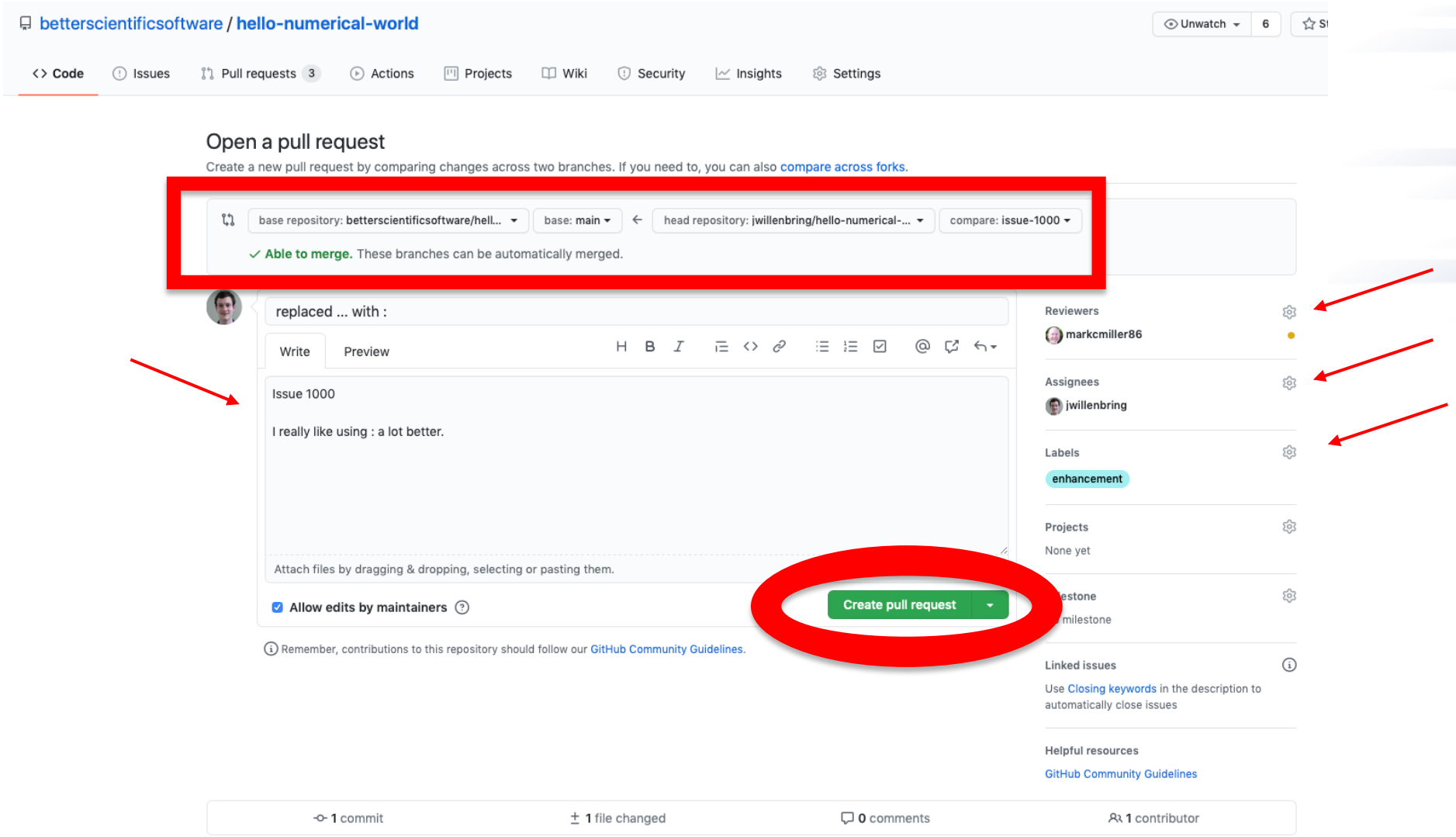
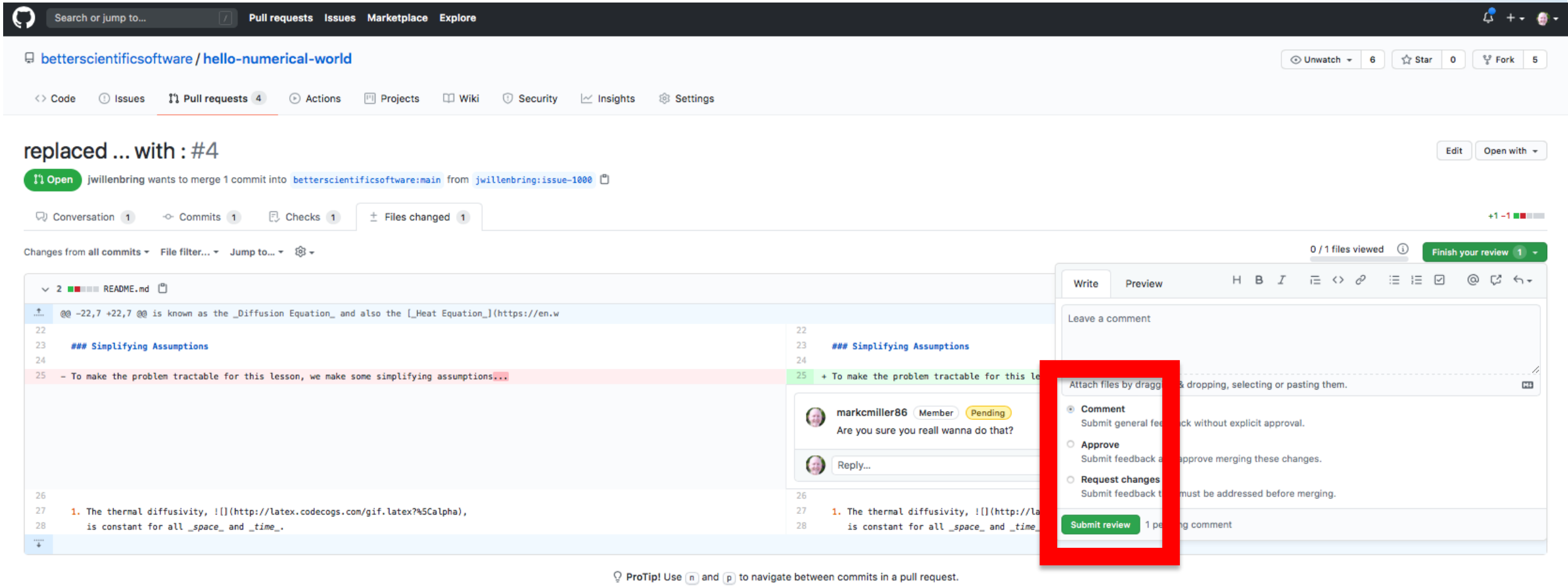
Issue Pull Request to Upstream Repository



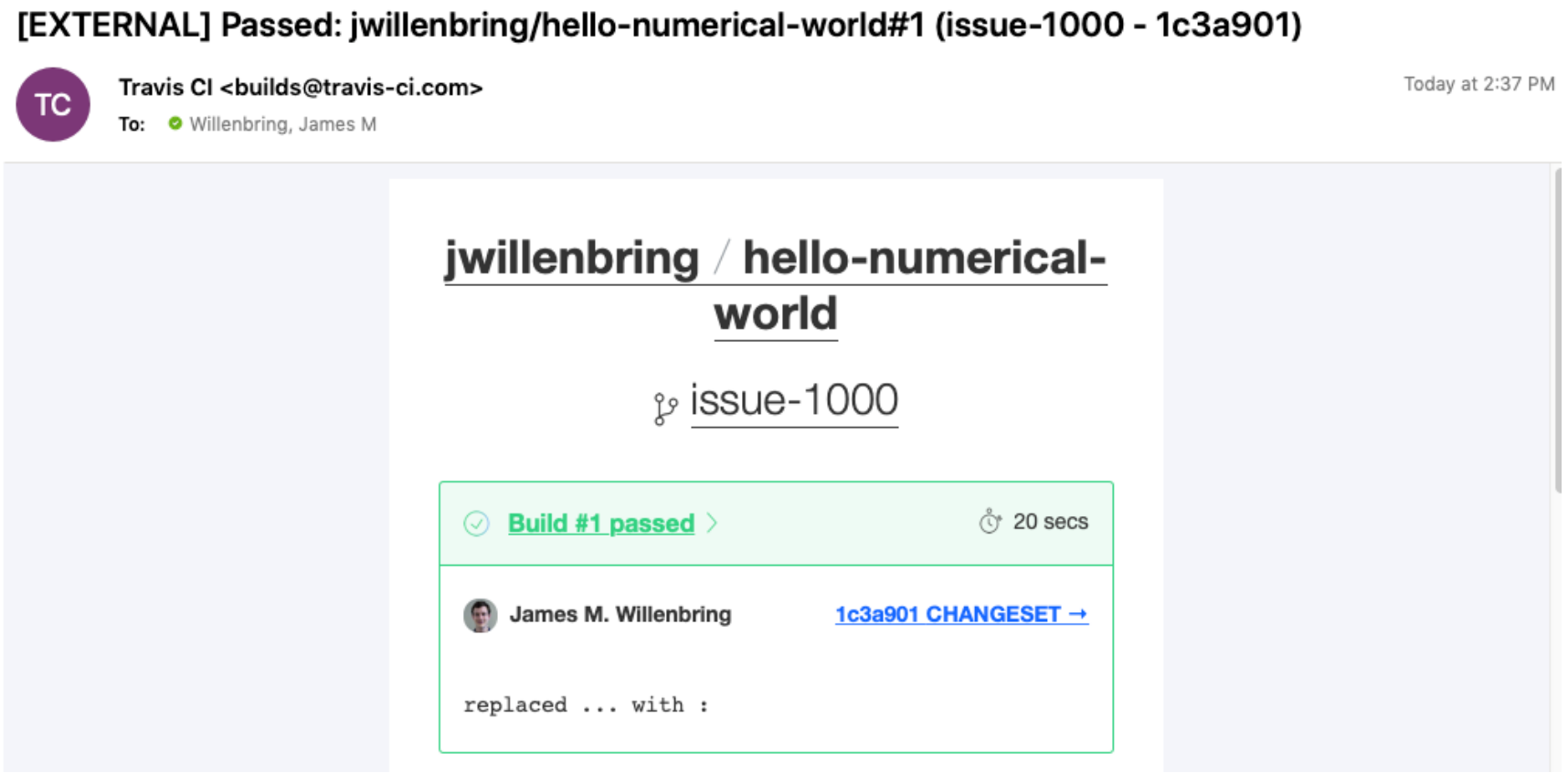
Issue Pull Request to Upstream Repository



Review Pull Request



CI Testing for PR



This will be covered in the CI module

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