

Software Engineering Techniques
for
Collaborative Software Development
Princeton University Bootcamp 2018

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October 30, 2018

Outline

Git and GitHub for Collaborative Developments

Testing

Automatic Testing

Other Useful Tools For Collaborative Software Development

References and Getting Help

Conclusion

Outline

Git and GitHub for Collaborative Developments

Testing

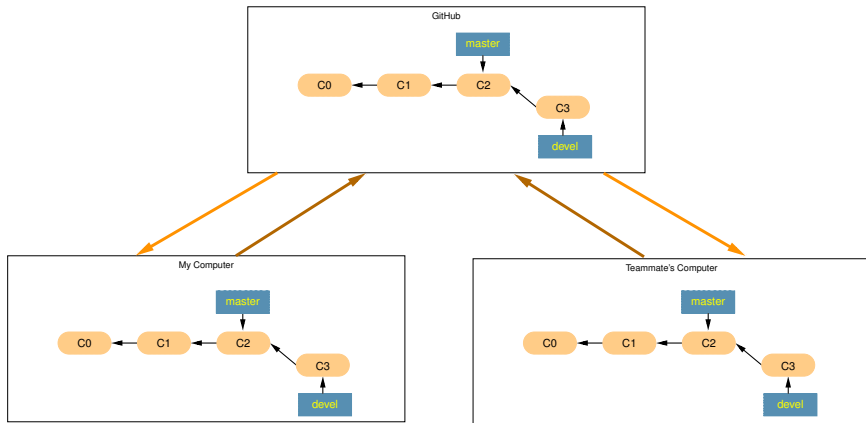
Automatic Testing

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A Simple Collaborative Workflow

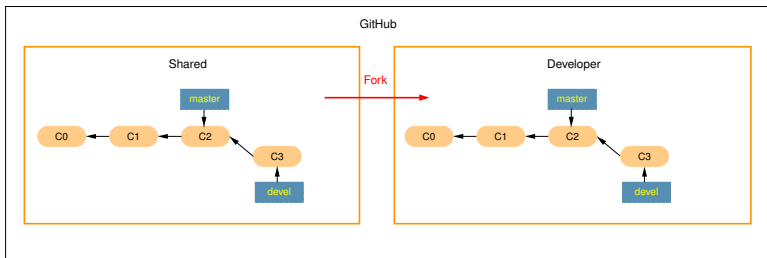


Remote Repository Permissions

- ▶ Problem with that simple workflow:
 - ▶ It's easy to push broken code to the shared repository.
 - ▶ when others pull the changes and start adding their development, it can create problem.
 - ▶ this does not work well with more than two developers.
- ▶ To solve this issue, we introduce two roles with different permissions on the shared repository:
 - ▶ code **maintainers**: **push and pull** permissions.
 - ▶ **developers**: **only pull** permission.

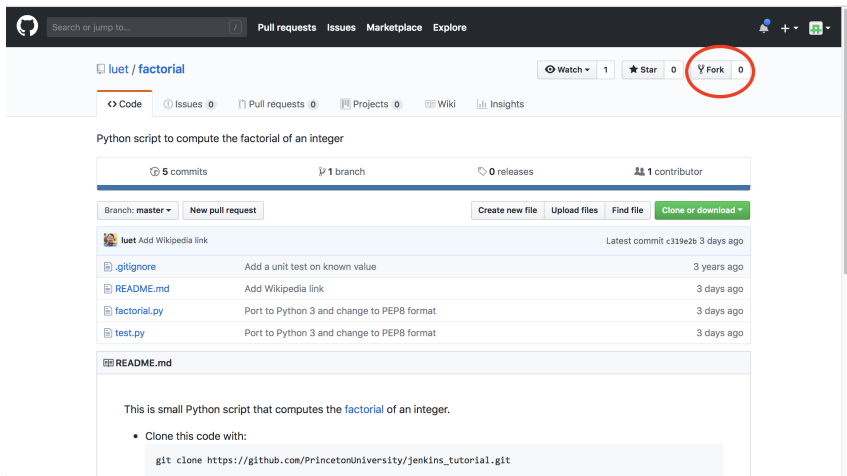
Forking a Repository on GitHub

Forks are basically a copy of a repo on GitHub.



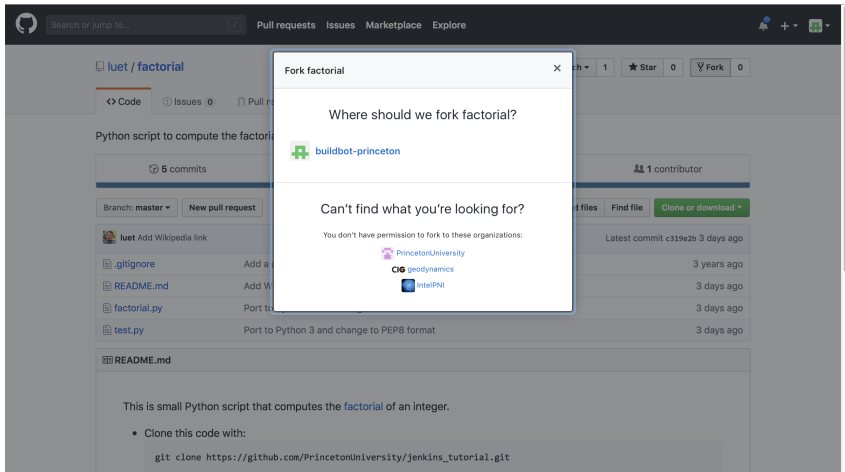
Forking a Repository on GitHub

As the GitHub user `buildbot-princeton` I want to fork:
<https://github.com/luet/factorial>



The screenshot shows the GitHub interface for the repository `luet/factorial`. At the top, there are navigation links for Pull requests, Issues, Marketplace, and Explore. The repository name `luet/factorial` is displayed, along with statistics for Watch (1), Star (0), and Fork (0). The 'Fork' button is circled in red. Below the repository name, there are tabs for Code, Issues (0), Pull requests (0), Projects (0), Wiki, and Insights. The main content area shows the repository's description: "Python script to compute the factorial of an integer". It also displays statistics: 5 commits, 1 branch, 0 releases, and 1 contributor. There are buttons for "Branch: master", "New pull request", "Create new file", "Upload files", "Find file", and "Clone or download". A list of files is shown, including `.gitignore`, `README.md`, `factorial.py`, and `test.py`. The `README.md` file is expanded, showing its content: "This is small Python script that computes the factorial of an integer." and a list item "Clone this code with:" followed by a code block containing the command `git clone https://github.com/PrincetonUniversity/jenkins_tutorial.git`.

Forking a Repository on GitHub



The screenshot shows the GitHub interface for the repository `luet / factorial`. A modal dialog titled "Fork factorial" is open, asking "Where should we fork factorial?". The dialog lists the organization `buildbot-princeton` as a suggestion. Below this, it states "Can't find what you're looking for?" and lists organizations that the user does not have permission to fork: `PrincetonUniversity`, `geodynamics`, and `intelPNI`.

Search or jump to... Pull requests Issues Marketplace Explore

luet / factorial

<> Code Issues 0 Pull requests

Python script to compute the factorial

5 commits

Branch: master New pull request

luet Add Wikipedia link

.gitignore Add a

README.md Add W

factorial.py Port to

test.py Port to Python 3 and change to PEP8 format

README.md

This is small Python script that computes the `factorial` of an integer.

- Clone this code with:
`git clone https://github.com/PrincetonUniversity/jenkins_tutorial.git`

1 Star 0 Fork 0

1 contributor

Files Find file Clone or download

Latest commit c319e2b 3 days ago

3 years ago

3 days ago

3 days ago

3 days ago

Forking a Repository on GitHub

The screenshot shows the GitHub interface for a repository named 'buildbot-princeton / factorial', which is a fork of 'luet/factorial'. The repository has 5 commits, 1 branch, 0 releases, and 1 contributor. The main branch is 'master'. A table of files is shown, including .gitignore, README.md, factorial.py, and test.py. The README.md content is visible at the bottom, stating: 'This is small Python script that computes the factorial of an integer.'

Search or Jump to... Pull requests Issues Marketplace Explore

buildbot-princeton / factorial
forked from luet/factorial

Unwatch 1 Star 0 Fork 1

Code Pull requests 0 Projects 0 Wiki Insights Settings

Python script to compute the factorial of an integer Edit

Manage topics

5 commits 1 branch 0 releases 1 contributor

Branch: master New pull request Create new file Upload files Find file Clone or download

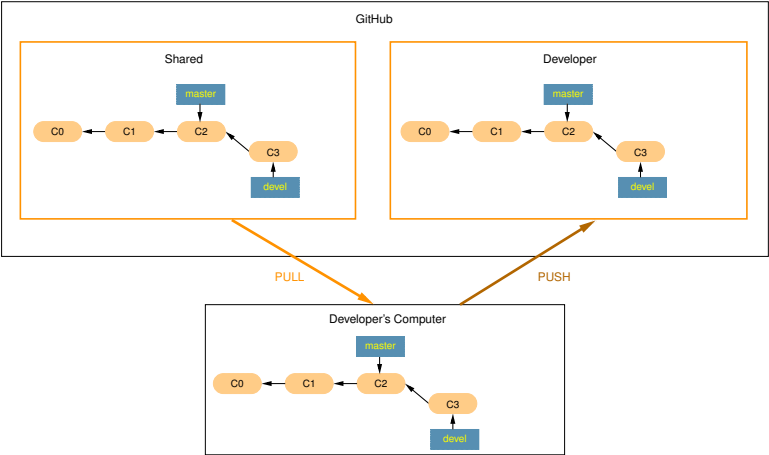
This branch is even with luet:master. Pull request Compare

luet	Add Wikipedia link	Latest commit c319e2b 3 days ago
.gitignore	Add a unit test on known value	3 years ago
README.md	Add Wikipedia link	3 days ago
factorial.py	Port to Python 3 and change to PEP8 format	3 days ago
test.py	Port to Python 3 and change to PEP8 format	3 days ago

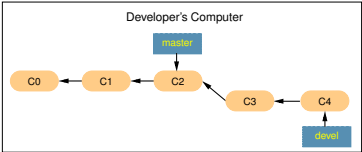
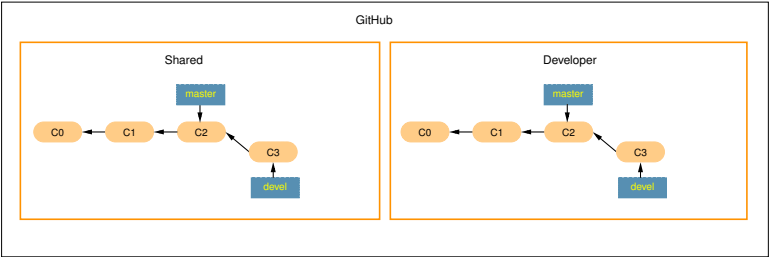
README.md Edit

This is small Python script that computes the **factorial** of an integer.

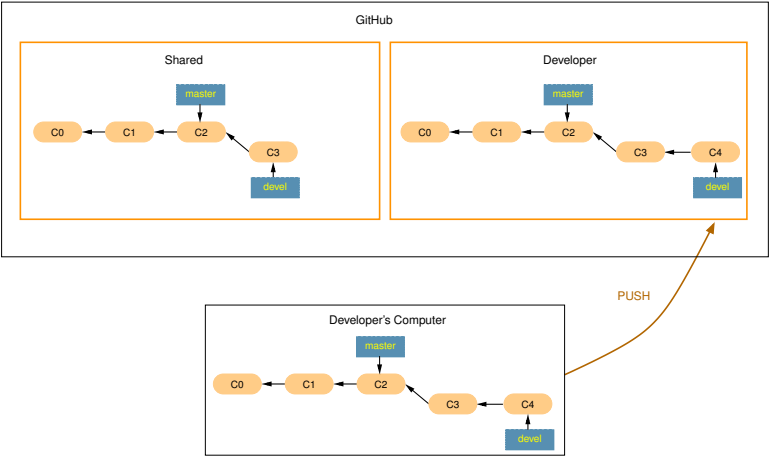
Pull-Request: the Different Repositories



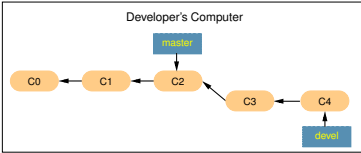
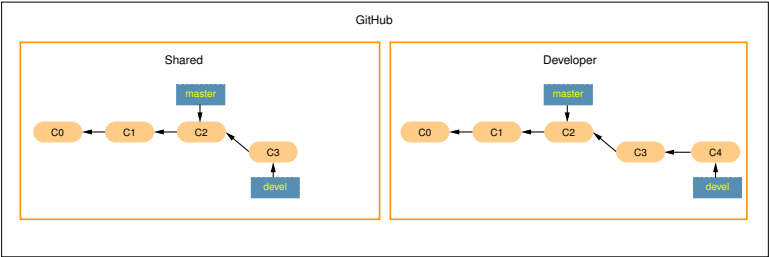
Pull-Request Steps



Pull-Request Steps



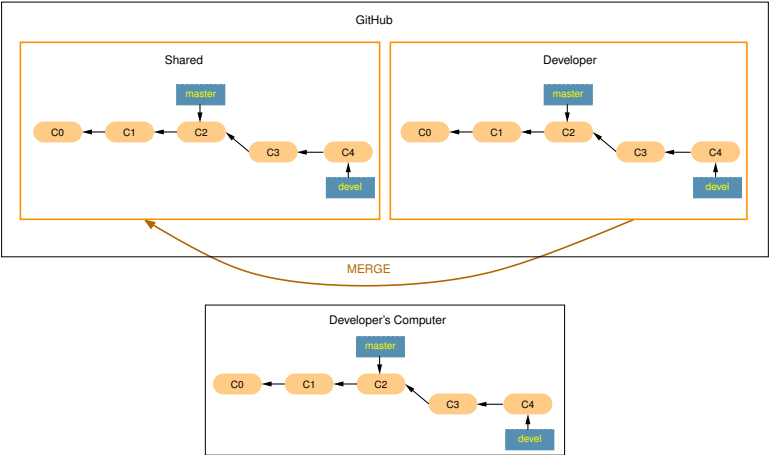
Pull-Request Steps



Open Pull-Request

GitHub

Pull-Request Steps



Pull-Request Steps on GitHub

Search or jump to... Pull requests Issues Marketplace Explore

buildbot-princeton / factorial
forked from luet/factorial

Unwatch 1 Star 0 Fork 1

Code Pull requests 0 Projects 0 Wiki Insights Settings

Python script to compute the factorial of an integer Edit

Manage topics

6 commits 1 branch 0 releases 1 contributor

Branch: master New pull request Create new file Upload files Find file Clone or download

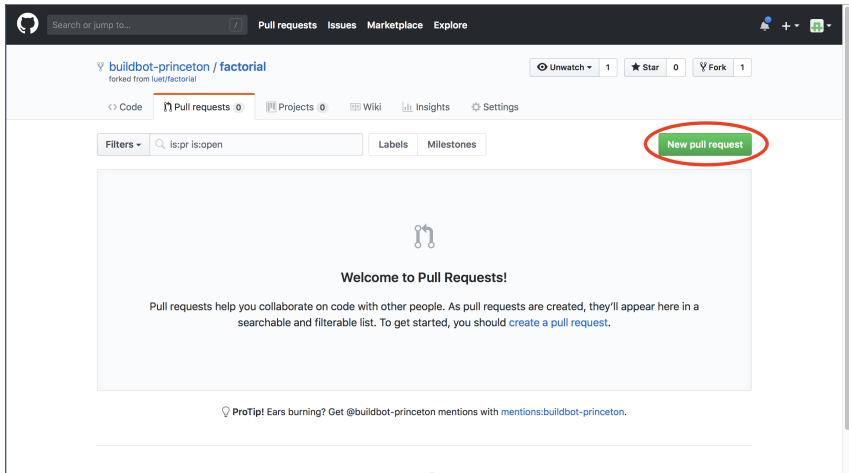
This branch is 1 commit ahead of luet:master. Pull request Compare

buildbot-princeton	Update README.md	Latest commit b24df86 12 seconds ago
.gitignore	Add a unit test on known value	3 years ago
README.md	Update README.md	12 seconds ago
factorial.py	Port to Python 3 and change to PEP8 format	3 days ago
test.py	Port to Python 3 and change to PEP8 format	3 days ago

README.md

This is small Python script that computes the factorial of an integer.

Pull-Request Steps on GitHub



The screenshot shows the GitHub interface for a repository. At the top, there is a navigation bar with 'Pull requests', 'Issues', 'Marketplace', and 'Explore'. Below this, the repository name 'buildbot-princeton / factorial' is displayed, along with statistics for 'Unwatch' (1), 'Star' (0), and 'Fork' (1). A secondary navigation bar includes 'Code', 'Pull requests' (0), 'Projects' (0), 'Wiki', 'Insights', and 'Settings'. A search bar with the filter 'is:pr is:open' is present, along with 'Labels' and 'Milestones' buttons. A prominent green button labeled 'New pull request' is circled in red. The main content area features a 'Welcome to Pull Requests!' message, explaining that pull requests facilitate collaboration and are listed in a searchable and filterable list. A 'ProTip!' at the bottom suggests using mentions like '@buildbot-princeton' or 'mentions:buildbot-princeton'.


Search or jump to... Pull requests Issues Marketplace Explore

buildbot-princeton / factorial
forked from luel/factorial

Unwatch 1 Star 0 Fork 1

Code Pull requests 0 Projects 0 Wiki Insights Settings

Filters is:pr is:open Labels Milestones **New pull request**



Welcome to Pull Requests!

Pull requests help you collaborate on code with other people. As pull requests are created, they'll appear here in a searchable and filterable list. To get started, you should [create a pull request](#).

ProTip! Ears burning? Get @buildbot-princeton mentions with [mentions:buildbot-princeton](#).


Pull-Request Steps on GitHub

The screenshot shows the GitHub interface for a repository named 'luet/factorial'. At the top, there are navigation links for 'Pull requests', 'Issues', 'Marketplace', and 'Explore'. The repository name 'luet/factorial' is displayed, along with statistics for 'Watch' (1), 'Star' (0), and 'Fork' (1). Below this, there are tabs for '<> Code', 'Issues 0', 'Pull requests 0', 'Projects 0', 'Wiki', and 'Insights'. The main heading is 'Comparing changes', with a subtext: 'Choose two branches to see what's changed or to start a new pull request. If you need to, you can also [compare across forks](#).' Below this, there are dropdown menus for 'base fork: luet/factorial', 'base: master', 'head fork: buildbot-princeton/factorial', and 'compare: master'. A green checkmark indicates 'Able to merge. These branches can be automatically merged.' A prominent green button labeled 'Create pull request' is circled in red. To its right, it says 'Discuss and review the changes in this comparison with others.' Below the button, there are statistics: '1 commit', '1 file changed', '0 commit comments', and '1 contributor'. A section for 'Commits on Oct 29, 2018' shows a commit by 'buildbot-princeton' titled 'Update README.md' with a 'Verified' badge and commit hash 'b24df86'. At the bottom, it states 'Showing 1 changed file with 2 additions and 0 deletions.' and shows a file named 'README.md' with a diff view.


Pull-Request Steps on GitHub

Open a pull request

Create a new pull request by comparing changes across two branches. If you need to, you can also [compare across forks](#).

 base fork: **luet/factorial** ▼ base: **master** ▼ ◀ head fork: **buildbot-princeton/factorial** ▼ compare: **master** ▼

✓ **Able to merge.** These branches can be automatically merged.



Write Preview AA B i ☰ <> ☰ ☰ ☰ @ 📎 ↶


Leave a comment

Attach files by dragging & dropping, [selecting them](#), or pasting from the clipboard.

Allow edits from maintainers. [Learn more](#)

Create pull request

↔ 1 commit 📁 1 file changed 💬 0 commit comments 👤 1 contributor

 Commits on Oct 29, 2018

Pull-Request Steps on GitHub

The screenshot shows a GitHub Pull Request interface for the repository `luet/factorial`. The title of the pull request is `Update README.md #1`. The pull request is from the `buildbot-princeton:master` branch to the `luet:master` branch. The interface includes a navigation bar with links for `Code`, `Issues`, `Pull requests`, `Projects`, `Wiki`, and `Insights`. The pull request details show `1` commit, `0` checks, and `1` file changed. A comment from `buildbot-princeton...` is visible, stating `No description provided.`. A green checkmark indicates that the branch has no conflicts with the base branch. The right sidebar shows sections for `Reviewers`, `Assignees`, `Labels`, `Projects`, and `Milestones`, all of which are currently empty.

Search or jump to... Pull requests Issues Marketplace Explore

luet / factorial Watch 1 Star 0 Fork 1

Code Issues 0 Pull requests 1 Projects 0 Wiki Insights

Update README.md #1

Open buildbot-prince... wants to merge 1 commit into luet:master from buildbot-princeton:master

Conversation 0 Commits 1 Checks 0 Files changed 1 +2 -0

buildbot-prince... commented just now

No description provided.

Update README.md Verified b24df86

Add more commits by pushing to the `master` branch on `buildbot-princeton/factorial`.

This branch has no conflicts with the base branch
Only those with [write access](#) to this repository can merge pull requests.

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Reviewers
No reviews

Assignees
No one assigned

Labels
None yet

Projects
None yet

Milestones
No milestone

Pull-Request Steps on GitHub

The screenshot shows a GitHub Pull Request (PR) page for the repository `luet/factorial`. The PR title is "Update README.md #1" and it is from the `buildbot-princeton` branch, wanting to merge 1 commit into the `luet:master` branch. The PR is currently open and has 1 commit, 0 checks, and 1 file changed. A comment from `buildbot-princeton` states "No description provided." A green checkmark indicates that the branch has no conflicts with the base branch. The right sidebar shows sections for Reviews, Assignees, Labels, Projects, and Milestones, all of which are currently empty. A user menu is open in the top right corner, showing the user is signed in as `buildbot-princeton` and listing options for profile, repositories, stars, gists, help, settings, and sign out.

Search or jump to... Pull requests Issues Marketplace Explore

luet / factorial Watch 1 Star 0

Code Issues 0 Pull requests 1 Projects 0 Wiki Insights

Update README.md #1

Open buildbot-prince... wants to merge 1 commit into luet:master from buildbot-princeton:master

Conversation 0 Commits 1 Checks 0 Files changed 1 +2

buildbot-prince... commented 2 minutes ago

No description provided.

Update README.md Verified b24df86

Add more commits by pushing to the `master` branch on `buildbot-princeton/factorial`.

This branch has no conflicts with the base branch
Only those with [write access](#) to this repository can merge pull requests.

Write Preview AA B i “ <> ☰ ☷ @ 🏠 ↶

Reviews: No reviews

Assignees: No one assigned

Labels: None yet

Projects: None yet

Milestones: No milestone

Signed in as buildbot-princeton

- Your profile
- Your repositories
- Your stars
- Your gists
- Help
- Settings
- Sign out

Pull-Request Steps on GitHub

Add more commits by pushing to the **master** branch on **buildbot-princeton/factorial**.



This branch has no conflicts with the base branch
Only those with [write access](#) to this repository can merge pull requests.



Write

Preview

AA B i ☞ <> ☁ ☰ ☷ ☹ @ 🏠 ↶

Leave a comment

Attach files by dragging & dropping, [selecting them](#), or pasting from the clipboard.

📄 Styling with Markdown is supported

Close pull request

Comment

💡 **ProTip!** Add `.patch` or `.diff` to the end of URLs for Git's plaintext views.

Labels

None yet

Projects

None yet

Milestone

No milestone

Notifications

🔔 Unsubscribe

You're receiving notifications because you authored the thread.

1 participant



Allow edits from maintainers.

[Learn more](#)



Pull-Request Steps on GitHub

The screenshot shows the GitHub interface for the repository 'luet / factorial'. The 'Pull requests' tab is highlighted with a red circle. The user profile dropdown menu is also open, with the text 'Signed in as luet' circled in red. The repository page displays the title 'Python script to compute the factorial of an integer', the number of commits (5), branches (1), and releases (0). A table of recent commits is visible, including one for adding a Wikipedia link and others for adding unit tests and porting to Python 3. The 'README.md' file is partially visible at the bottom, containing a description of the Python script and a list item 'Clone this code with:'.

Search or jump to... Pull requests Issues Marketplace Explore

luet / factorial Unwatch 1

Code Issues 0 Pull requests 1 Projects 0 Wiki Insights Settings

Python script to compute the factorial of an integer

Manage topics

5 commits 1 branch 0 releases

Branch: master New pull request Create new file Upload files Find file Clone or download

Commit	Message	Time
luet	Add Wikipedia link	Latest commit c319e2b 3 days ago
.gitignore	Add a unit test on known value	3 years ago
README.md	Add Wikipedia link	3 days ago
factorial.py	Port to Python 3 and change to PEP8 format	3 days ago
test.py	Port to Python 3 and change to PEP8 format	3 days ago

README.md

This is small Python script that computes the **factorial** of an integer.

- Clone this code with:

Pull-Request Steps on GitHub

The screenshot shows the GitHub web interface for the repository 'luet / factorial'. At the top, there is a navigation bar with the GitHub logo, a search bar, and links for 'Pull requests', 'Issues', 'Marketplace', and 'Explore'. On the right side of the navigation bar, there are icons for notifications, a plus sign, and a user profile.

Below the navigation bar, the repository name 'luet / factorial' is displayed. To the right of the repository name are buttons for 'Unwatch' (1), 'Star' (0), and 'Fork' (1). Below this, there are navigation tabs for 'Code', 'Issues' (0), 'Pull requests' (1), 'Projects' (0), 'Wiki', 'Insights', and 'Settings'. The 'Pull requests' tab is currently selected and highlighted with an orange underline.

In the center of the page, there is a message box titled 'Label issues and pull requests for new contributors'. The text reads: 'Now, GitHub will help potential first-time contributors discover issues labeled with help wanted or good first issue'. There is a 'Dismiss' link on the right side of the message box.

Below the message box, there is a 'Filters' section with a search input containing 'is:pr is:open'. To the right of the filters is a 'New pull request' button. Below the filters, there is a table of pull requests. The table has columns for 'Author', 'Labels', 'Projects', 'Milestones', 'Reviews', 'Assignee', and 'Sort'. The first row in the table shows a pull request titled 'Update README.md' with the description '#1 opened 8 minutes ago by buildbot-princeton'. There is a checkbox to the left of the pull request title.

At the bottom of the page, there is a footer with the copyright notice '© 2018 GitHub, Inc.', links for 'Terms', 'Privacy', 'Security', 'Status', and 'Help', the GitHub logo, and links for 'Contact GitHub', 'Pricing', 'API', 'Training', 'Blog', and 'About'.

Pull-Request Steps on GitHub

The screenshot displays a GitHub pull request page. At the top, a comment from 'buildbot-princet...' is visible. Below it, a commit titled 'Update README.md' is shown. A message indicates that continuous integration is not set up but that the branch has no conflicts with the base branch. A green button labeled 'Merge pull request' is circled in red. Below this is a comment input area with a 'Close pull request' button and a 'Comment' button. On the right side, there are sections for 'Reviewers', 'Assignees', 'Labels', 'Projects', 'Milestone', and 'Notifications'.

buildbot-princet... commented 9 minutes ago First-time contributor

No description provided.

Update README.md Verified b24df86

Add more commits by pushing to the **master** branch on **buildbot-princeton/factorial**.

Continuous integration has not been set up
Several apps are available to automatically catch bugs and enforce style.

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 AA B i ↵ ↶ ↷ ↻ ☰ ☷ ☹ @ 🏠 ↶

Leave a comment

Attach files by dragging & dropping, [selecting them](#), or pasting from the clipboard.

Styling with Markdown is supported Close pull request Comment

Reviewers ⚙
Suggestions
luet [Request](#)

Assignees ⚙
No one—assign yourself

Labels ⚙
None yet

Projects ⚙
None yet

Milestone ⚙
No milestone

Notifications
Unsubscribe
You're receiving notifications because you're watching this repository.

1 participant
👤

Lock conversation

ProTip! Add comments to specific lines under [Files changed](#).

hands-on #1

<http://luet.princeton.edu/cicd/>

Advantages of Doing a Pull-Request?

- ▶ Gives us time to review and test the changes before committing them.
- ▶ So that no broken code gets committed to the shared repository.
- ▶ The problem with this simple workflow is that it can be hard for the code maintainers to know whether or not changes break the code.
- ▶ That's why we need to build some tests.

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Definition and Motivation

- ▶ **Debugging** is what you do when you know that a program is broken.
- ▶ **Testing** is a determined, systematic attempt to break a program that you think is working.
- ▶ Testing for **Quality Assurance**: make sure some changes didn't change the results compared to the last version.
- ▶ When you write code with testing in mind, you write better code because you write better interfaces.

When to Write the Tests

- ▶ Test while you are writing the code.
- ▶ **Test incrementally:**
 - ▶ write part of a program,
 - ▶ test it,
 - ▶ add some more code,
 - ▶ test that,
 - ▶ and so on.
- ▶ Some programming techniques (e.g. Extreme Programming) even instruct you to write the tests first.

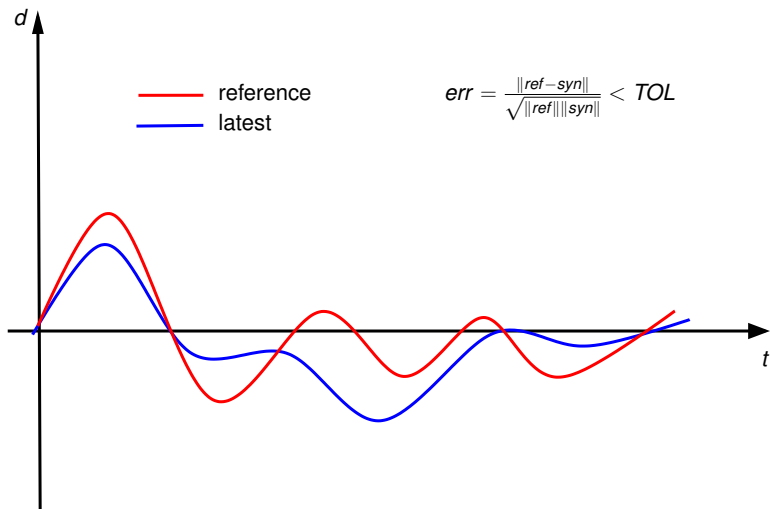
Testing for Functionality

- ▶ Unit testing: test one function.
- ▶ Test a set of functions or the entire code:
 - ▶ It can be hard to design a test that will exercise a certain portion of your code by running the entire code.
 - ▶ Use libraries and drivers to isolate functions or a group of functions.

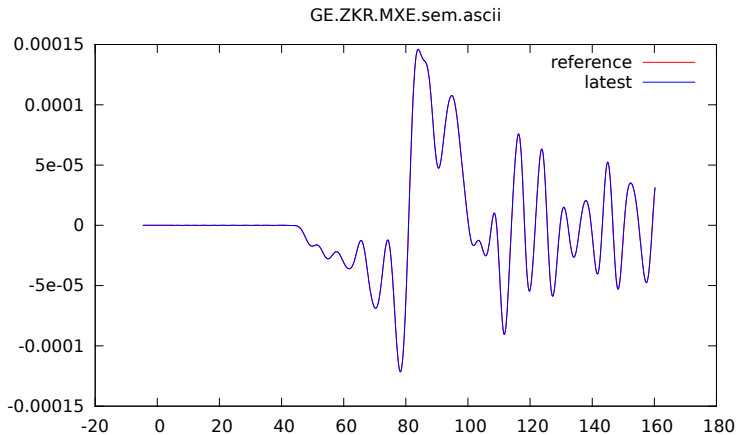
Regression Testing: An Example

- ▶ SPECFEM3D_GLOBE (Tromp et. al): simulates global and regional seismic wave propagation.
- ▶ This code produces seismograms, which are records of the ground motion in one direction at a measuring station as a function of time.

Regression Testing: Comparing Seismograms



An Actual Seismograms



Other Tests

- ▶ Use different compilers to:
 - ▶ check that it will compile.
 - ▶ find programming mistakes.
 - ▶ compare the results.
- ▶ Use different versions of scripting languages e.g. Python, Matlab.
- ▶ Run on different OS, hardware to make sure:
 - ▶ the code runs.
 - ▶ the code gives the same results.

Testing frameworks

- ▶ Google framework for C++: [Google Test](#).
- ▶ Python: [unittest](#)
- ▶ [Matlab](#)

Testing Frameworks Example

- ▶ Look at my factorial calculation repository:
<https://github.com/luet/factorial/>

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Why Run Test Automatically?

- ▶ The temptation when you develop code is to test only that part that you just wrote.
 - ▶ But there might be **side effects** to your changes.
 - ▶ So you want to run a your **entire suite of tests** every time you make a change.
 - ▶ you are less likely to do that if the tests have to be run manually.
- ▶ Not all the developers have access to all tools.
- ▶ Once it's set up you don't have to spend any time running your tests.

Test Automation with Travis

- ▶ An example:
https://github.com/uvaaland/travis_tutorial
- ▶ You can get a free account at <https://travis-ci.com/>.
- ▶ When you can login with your GitHub credential.
- ▶ It's only really free for open source (public repositories).

Test Automation with Jenkins

- ▶ Service offered by Research Computing.
- ▶ Jenkins is a web-based application for automatic testing.
- ▶ Simple user interface: easy to configure.
- ▶ The advantage other Travis is that with Jenkins you have access to the Research Computing resources:
 - ▶ Large number of cores.
 - ▶ Compilers.
 - ▶ Licensed software e.g. Matlab.
- ▶ Email `cses@princeton.edu` to request an account.
- ▶ There is a tutorial at:
<http://jenkins-doc.princeton.edu/tutorial.html>

A Workflow with Jenkins and GitHub

Typical workflow:

1. A Pull-Request is open on GitHub.
2. GitHub sends a signal to our Jenkins server (webhook).
3. Jenkins runs the tests suite.
4. Jenkins reports the results of the tests on the GitHub web site.
 - ▶ If the changes passed the test, the code maintainer can merge the changes.
 - ▶ If the changes failed the test, the developer needs to solve the problem and push the changes to Github.

Scheduled Tests

- ▶ A Pull-Request only triggers short (< 15 min) tests.
- ▶ We use Jenkins to schedule longer tests:
 - ▶ daily (< 1 hour).
 - ▶ weekly (> 1 hour).

Jenkins vs. Travis

- ▶ With Jenkins you can run on:
 - ▶ the Research Computing clusters.
 - ▶ any machine that you have `ssh` access to.
- ▶ Travis is good for small scripts, not parallel code.

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Code Documentation

- ▶ It's important to document your code when someone else will have to read it.
 - ▶ especially when this someone else can be you in a couple years.
- ▶ **Doxygen:**
 - ▶ Documentation is in the code.
 - ▶ Supports adding Latex to the documentation.
 - ▶ Build calling graph.
 - ▶ *show example*
- ▶ You can use Sphinx with Python.

Documenting outside the code: GitHub Wiki

- ▶ GitHub Wiki

- ▶ It's easy to write in [Markdown](#).

- ▶ <https://help.github.com/articles/about-github-wikis/>

- [//help.github.com/articles/about-github-wikis/](https://help.github.com/articles/about-github-wikis/)

- ▶ *show examples*

- ▶ Issues:

- ▶ <https://guides.github.com/features/issues/>

- ▶ Like a shared TODO list.

- ▶ Gists:

- ▶ <https://gist.github.com/>

- ▶ For sharing small codes.

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References

- ▶ The Practice of Programming, by Brian W. Kernighan and Rob Pike.
- ▶ Testing with Python:
 - ▶ The Hitchhiker's Guide to Python!:
<http://docs.python-guide.org/en/latest/>
 - ▶ Testing your code: <http://docs.python-guide.org/en/latest/writing/tests/#testing-your-code>
- ▶ Agile development: [Manifesto for Agile Software Development](#)

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Conclusion

- ▶ I encourage you to, in order of urgency:
 - ▶ use a Version Control System.
 - ▶ design some tests.
 - ▶ run those tests automatically.
- ▶ In the long run, it will:
 - ▶ **save you some time** in debugging and troubleshooting.
 - ▶ let you **modify your code with confidence** that you are not breaking it.
 - ▶ generate a **better organized** and **better written** code.
- ▶ We are here to help.
 - ▶ You can e-mail us at: cses@princeton.edu.
 - ▶ Come to the help sessions Tuesdays (10-11 am) and Thursdays (2-3 pm), room 347 Lewis Library.
- ▶ Job opportunity for Graduate students.