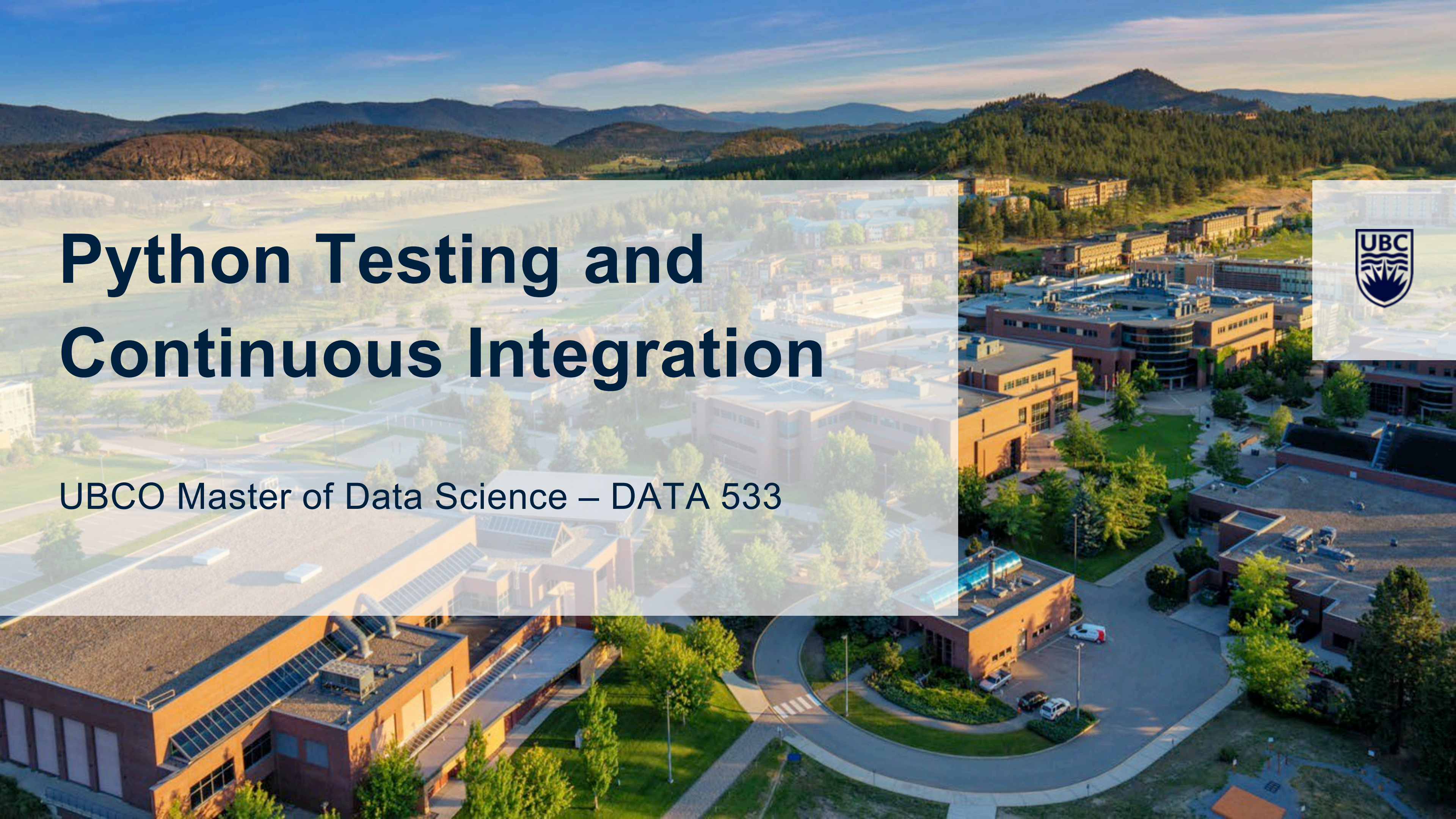


Python Testing and Continuous Integration

UBCO Master of Data Science – DATA 533

Today's Class

Python modules and packages

- Python OOP (L1-2)
- Modules and Packages (L3)
- Collaborative version control (L4)
- Testing, CI/CD, Error and Exception (L5-7)
- Publishing packages (L8)

$\Bigg\}$ Design an application in collaboration

Making importable modules and packages

- Using the `import` statement
- Install other people's packages and modules

Today's Class

Levels of Software Testing

Black and White Box Testing

Code Coverage In Python

Continuous Integration (CI)

- Use Travis-CI

Unit Testing

The foundational level of software testing is unit testing.

Unit testing specifically tests a single ***unit*** of code in isolation.

A unit is often a function or a method of a class instance.

```
def addition(num1, num2):
    return num1 + num2
```

One Unit

```
def subtraction(num1, num2):
    return num1 - num2
```

Another Unit

Levels of Test

Integration Tests: exercise groups of components to ensure that their contained units interact correctly together.

Acceptance Tests: focus on the business cases rather than the components themselves.

A|B: A special subset of testing that is typically employed in production environments. In A|B testing, two different versions are compared at runtime to validate which one performs 'best’.

UI Tests: make sure that the application functions correctly from a user perspective.

https://github.com/ubccpsc/310/blob/main/resources/readings/Testing.md

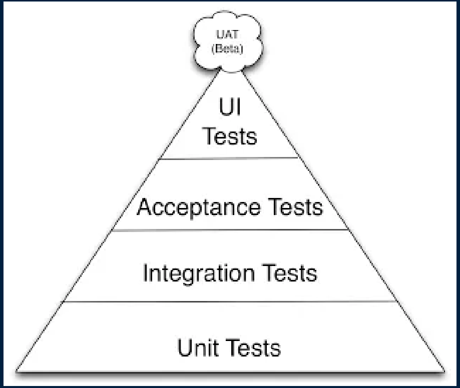
Levels of Test

Unit tests are fast and cheap to implement

- They're mostly doing checks on small pieces of code.

UI tests will be complex to implement

- Often require to get a full environment started as well as multiple services to emulate browser or mobile behaviours.



You may want to limit the number of complex UI tests and rely on good Unit testing at the base to have a fast build and get feedback to developers as soon as possible.

Black and White Box Testing

White box tests: Written with knowledge of the implementation of the code under test.

- Focuses on internal states of objects and code
- Focuses on to cover all code paths/statements
- Unit testing is often the first type of testing done on an application

Black box tests: written without knowledge of how the class/module/package under test is implemented

- Focuses on the input/output of each component or call
- Black box testing can be applied to virtually every level of software testing: unit, integration, and acceptance.

Black Box Testing

Validates that the output is correct (according to the specification) for a given set of inputs.

Write a comprehensive set of test cases for the maximum function on the board.

```
def maximum(a, b):
# Return the larger numerical input, a or b
```

White Box Testing

White-box testing is testing that takes into account the internal mechanism of a system or component.

White-box testing is also known as structural testing, clear box testing, and glass box testing.

Write a comprehensive set of test cases for the maximum function on the board.

```
def maximum(a, b):
    if (a > b):
        return a
    else:
        return b
```

Testing Question

Question: In ___________, two different versions are compared at runtime to validate which one performs 'best'

A) Unit tests.

B) Integration tests.

C) Acceptance tests.

D) End-to-End tests.

E) A|B tests

Testing Question

Question: How many of the following statements are TRUE?

A) White-box testing requires preparing test cases to exercise the internal logic of a software module.

B) Black box testing focuses on input/output of each component or call

C) UI Tests make sure that the application functions correctly from business cases perspective.

D) Implementation knowledge is required for black box testing.

A) 0 **B)** 1 **C)** 2 **D)** 3 **E)** 4

Code Coverage

Test cases should examine the code and choose tests that exercise as much of the code as possible.

Code coverage

- Is usually reported as the percentage of overall code that is exercised.
- A program with high test coverage has had more of its source code executed during testing
- It suggests whether a program has a lower or higher chance of containing undetected software bugs.

Coverage.py: https://coverage.readthedocs.io/

Code Coverage

Method/Function coverage:

- how many of the functions defined have been called.

Statement coverage:

- how many of the statements in the program have been executed.

Branches coverage:

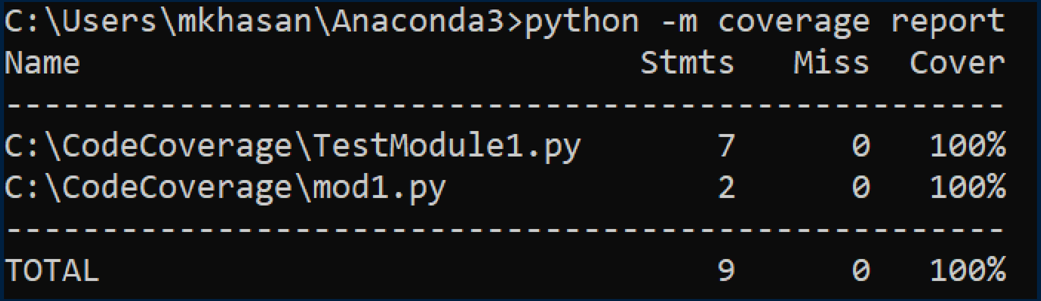
- how many of the branches of the control structures (if statements for instance) have been executed.

Code Coverage In Python

Install coverage: `python -m pip install coverage`

Run the test file: `python -m coverage run` *`test_file_path`*

Show the report : `python -m coverage report`



```
C:\Users\mkhasan\Anaconda3>python -m coverage report
Name                              Stmts   Miss  Cover
-----------------------------------------------------
C:\CodeCoverage\TestModule1.py        7      0   100%
C:\CodeCoverage\mod1.py               2      0   100%
-----------------------------------------------------
TOTAL                                 9      0   100%
```

Produce an HTML report: `coverage html`

- This command will create a folder named **htmlcov** that contains various files. Navigate into that folder and try opening **index.html**

Try it: Code Coverage

Steps:

1. Download `grades.py` and `test_grades.py` files from `\lecture6\code\code coverage` folder

2. Install `Coverage.py` and execute commands to run the `test_grades.py` file to check the code coverage results

3. Now remove the `#` signs from the `test_grades.py` file, run the test code and check the coverage results again

General Guidelines

Integrate early and often:

- It is important that developers integrate their changes as soon as possible on the main repository, avoid “merge hell”

Keep the build green at all time

- Building means transforming your high-level code into a format your computer knows how to run.
- If a developer breaks the build for a branch, fixing it becomes the main priority.

Write tests as part of your stories

- You need to make sure that every feature that gets developed has automated tests.

Write tests when fixing bugs

- Make sure that you add tests when you fixing them from occurring again.

Continuous Integration

Continuous integration (CI) is the practice of frequently building and testing each change done to your code automatically and as early as possible.

Pioneered by Martin Fowler

"Continuous Integration is a software development practice where members of a team integrate their work frequently, usually each person integrates at least daily - leading to multiple integrations per day. Each integration is verified by an automated build (including test) to detect integration errors as quickly as possible." - Martin Fowler

Continuous Integration (CI)

Start writing tests for the critical parts of your codebase.

Get a CI service to run those tests automatically on every push to the main repository.

Make sure that your team integrates their changes everyday.

Fix the build as soon as it’s broken.

Write tests for every new story that you implement.

CI Providers

Travis

- Free for open source, most popular

Jenkins

- Host yourself, configure yourself (OpenShift)

CircleCI

- Supports private projects
- Free 1500 minutes of builds per month

- others: GitHub Action, Shippable, drone.io, appveyor

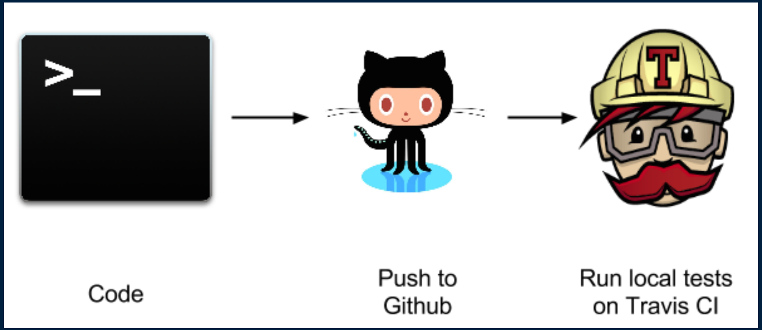
Travis CI: How Does It Work?

1. Sign in to Travis CI with your GitHub account, accepting the GitHub access permissions confirmation.

2. Once you’re signed in, and Travis CI synchronized your repositories from GitHub, go to your profile page and enable Travis CI for the repository you want to build.

Travis CI: How Does It Work?

3. Add a `.travis.yml` file to your repository to tell Travis CI what to build.
4. Add the `.travis.yml` file to git, commit and push, to trigger a Travis CI build.
5. Check the build status page to see if your build passes or fails.



Travis: Configuration Steps

Create a new repository on GitHub

- Visit https://github.com/USERNAME.
- Click Repositories tab.
- Click New.
- Enter Repository name: InClassCI2023
- Click Create repository

Clone your Repo locally

- `$ git clone URL`
- `$ cd InClassCI2023`

Travis: Configuration Steps

Copy `lectures/lecture6/code/Travis CI/mod1.py` and Copy `lectures/lecture6/code/Travis CI/TestModule1.py`

Add and commit this file to your repository and push the changes to GitHub:

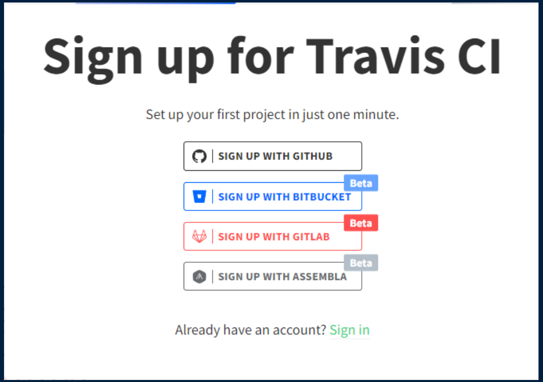
```
$ git add .
$ git commit -m "Added Unit test code"
$ git push
```

Visit `https://github.com/USERNAME/InClassCI2023` and check that the repository now contains all the files.

Travis: Configuration Steps

Sign in to Travis CI

- Once you have an account on GitHub, you can use this to sign in to Travis CI, so go to Travis CI, https://education.travis-ci.com/
- Click on Sign in with GitHub.


Sign up for Travis CI

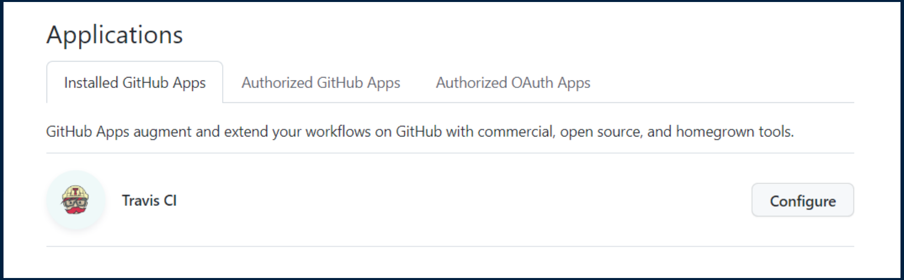
Set up your first project in just one minute.

Already have an account? Sign in

In GitHub

Settings -> Integrations -> GitHub Apps

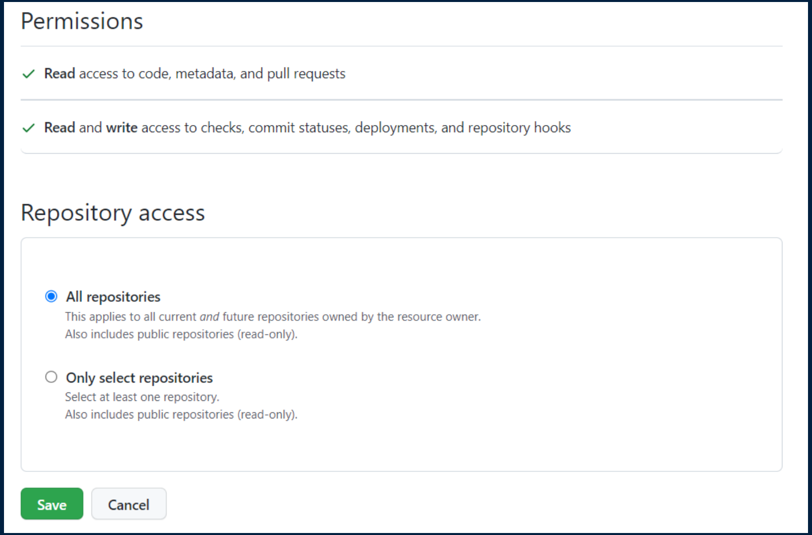
You can also see the permissions and access to repositories



Applications

GitHub Apps augment and extend your workflows on GitHub with commercial, open source, and homegrown tools.

Travis CI



Permissions

✓ **Read** access to code, metadata, and pull requests

✓ **Read** and **write** access to checks, commit statuses, deployments, and repository hooks

Repository access

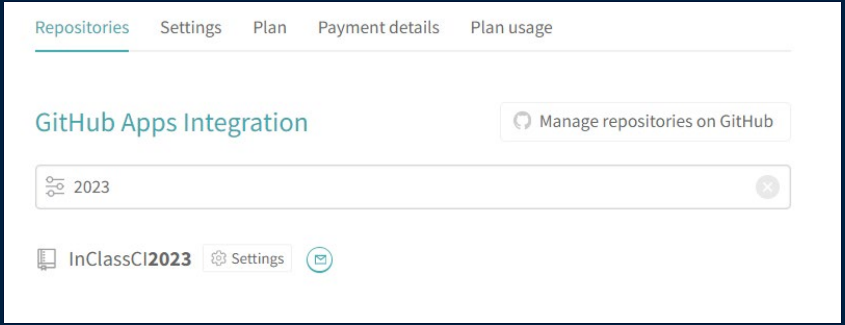
● **All repositories**
This applies to all current *and* future repositories owned by the resource owner.
Also includes public repositories (read-only).

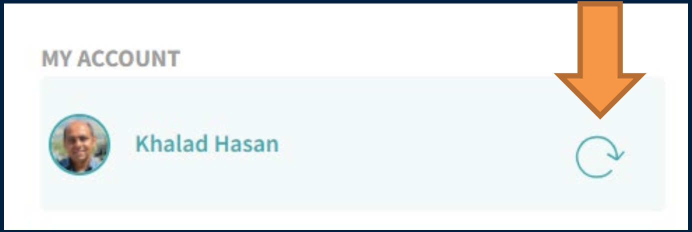
○ **Only select repositories**
Select at least one repository.
Also includes public repositories (read-only).

Travis: Configuration Steps

Enable your repository on Travis CI

- Go to `https://app.travis-ci.com/account/repositories` which shows a list of your GitHub repositories that Travis CI knows about.
- If you cannot see `USERNAME/InClassCI2023`, then go to settings and click the Sync account button which tells Travis CI to check your current repositories on GitHub.
- When you can see `USERNAME/InClassCI2023`, then click on the link to monitor that repository for changes.





Travis: Configuration Steps

Create and add a `.travis.yml` job file

- Travis CI looks for a file called `.travis.yml` in a Git repository.
- This file tells Travis CI how to build and test your software.
- In addition, this file can be used to specify any dependencies you need installed before building or testing your software.

Create `.travis.yml` with the content:

```
language: python
python:
  - "3.4"
  - "3.5"
script:
  - python TestModule1.py
```

Build Configuration

Language:

- is used to specify the language of the software.

Python:

- is used to specify the version or versions of Python to use for testing.

Install:

- is used to specify commands to run before testing, such as the installation of dependencies or the compilation of required packages.

Script:

- section is used to specify the command to test your software.
- The specified command must exit with a status code of 0 if the test is successful; otherwise the test will be considered a failure.

Travis: Configuration Steps

Add and commit this file to your repository and push the changes to GitHub:

```
$ git add .
$ git commit -m "Added Travis CI job file"
$ git push
```

Visit `https://github.com/USERNAME/InClassCI2023` and check that the repository now contains `.travis.yml`.

Explore the Travis CI job information

Visit `https://education.travis-ci.com/`

You should see a job called `InClassCI2023`. Jobs are named after the corresponding repositories.

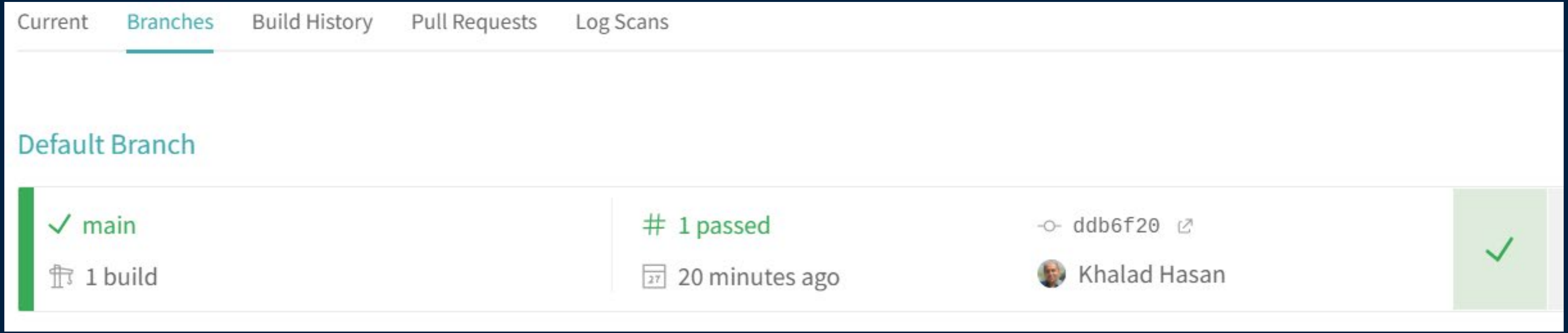
Click on `InClassCI2023`.

This will take you to a page, which shows information about the run of your Travis CI job.

The job should be coloured green and with a check/tick icon which means that the job succeeded.

Travis: Branches

Displays the most recent build for each branch (only main branch)

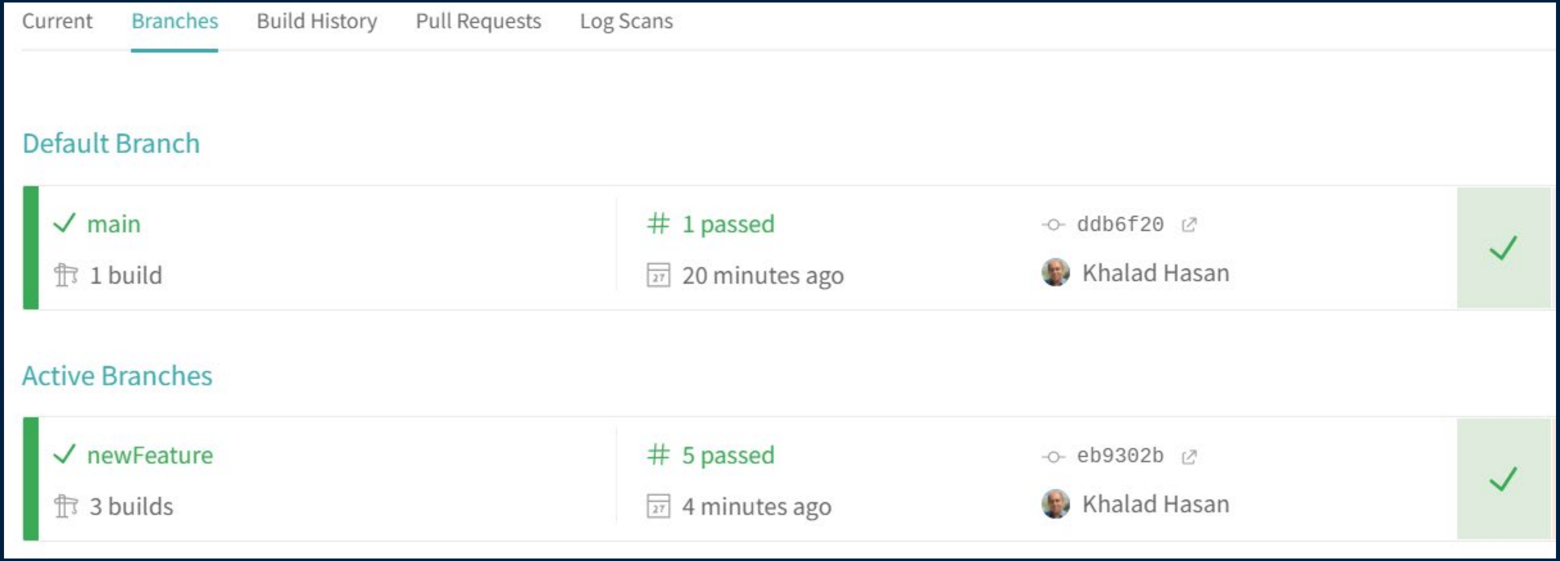


Default Branch

✓ main
1 build
1 passed
20 minutes ago
ddb6f20
Khalad Hasan

Travis: Branches

Displays the most recent build for each branch (main branch and a new branch)



Default Branch

✓ main
1 build
1 passed
20 minutes ago
ddb6f20
Khalad Hasan
✓

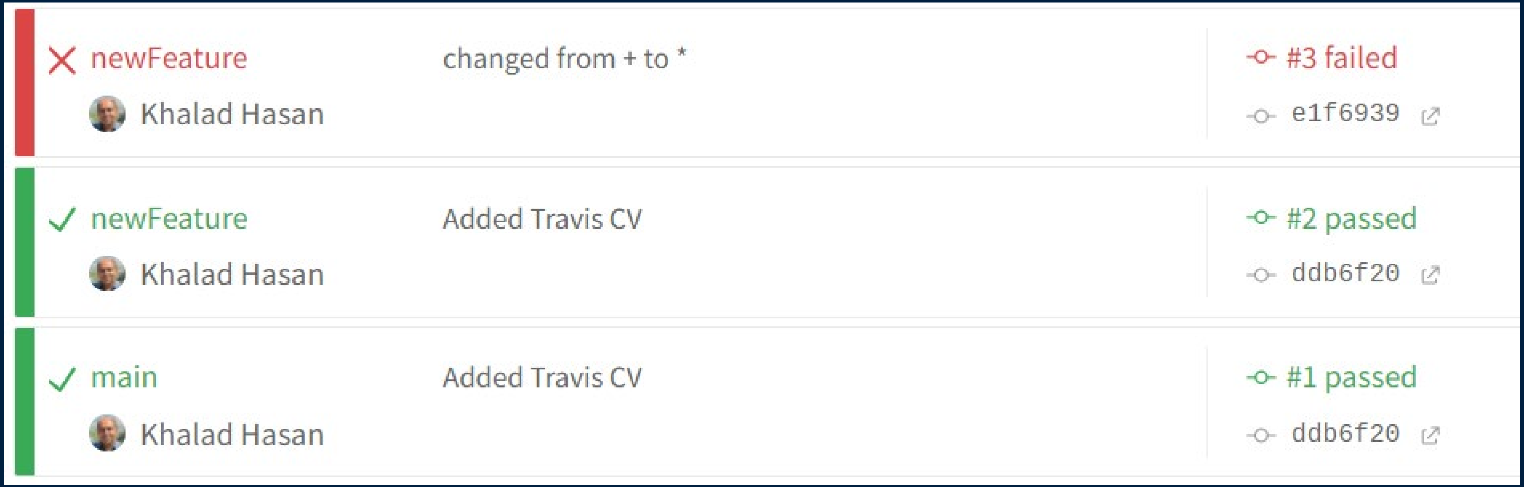
Active Branches

✓ newFeature
3 builds
5 passed
4 minutes ago
eb9302b
Khalad Hasan
✓

Travis: Branches

Added an error to the newFeature branch (Build History Tab)

```
def addition(num1, num2):
    return num1 * num2
```

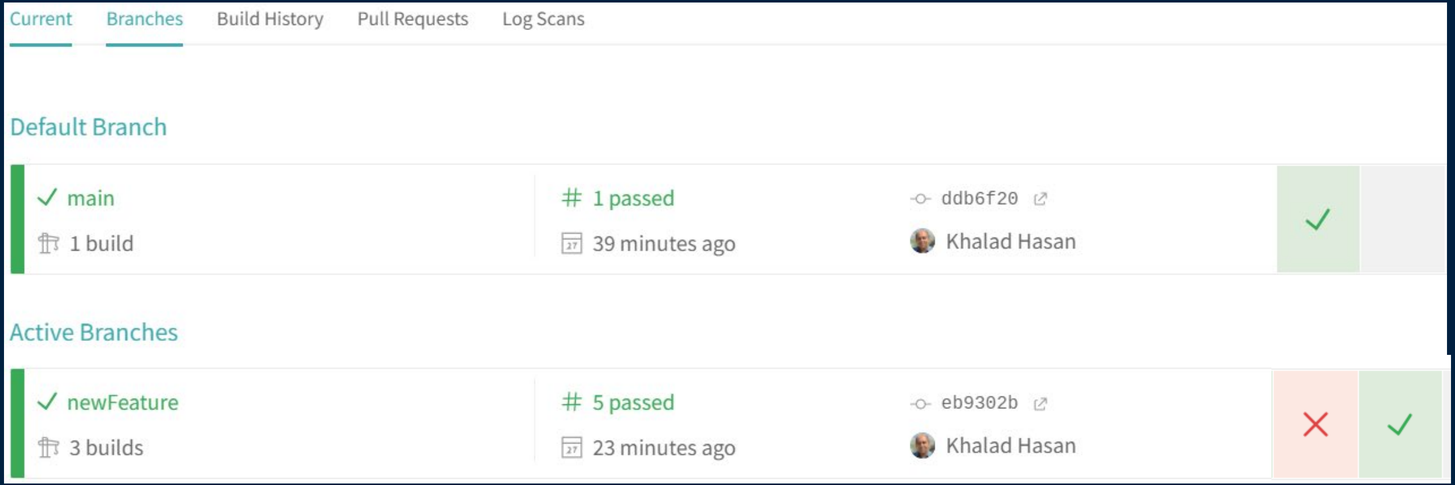


✗ newFeature	Khalad Hasan	changed from + to *	#3 failed e1f6939
✓ newFeature	Khalad Hasan	Added Travis CV	#2 passed ddb6f20
✓ main	Khalad Hasan	Added Travis CV	#1 passed ddb6f20

Travis: Branches

Added an error to the newFeature branch

```
def addition(num1, num2):
    return num1 * num2
```



Default Branch

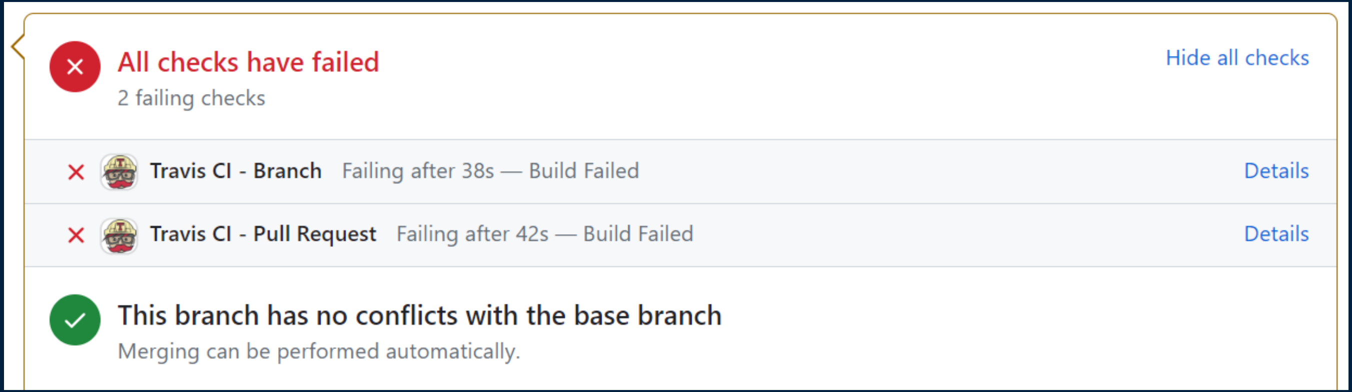
✓ main
1 build
1 passed
39 minutes ago
ddb6f20
Khalad Hasan

Active Branches

✓ newFeature
3 builds
5 passed
23 minutes ago
eb9302b
Khalad Hasan

Pull Request

GitHub will slow the following error message


All checks have failed
2 failing checks

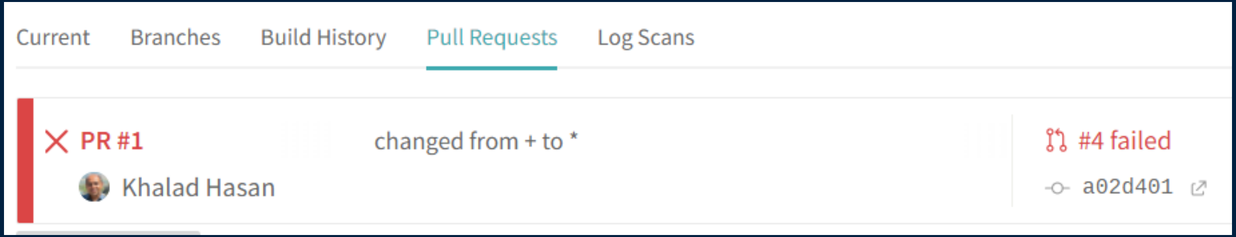
Hide all checks

× Travis CI - Branch Failing after 38s — Build Failed Details

× Travis CI - Pull Request Failing after 42s — Build Failed Details

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

Travis will show the following:

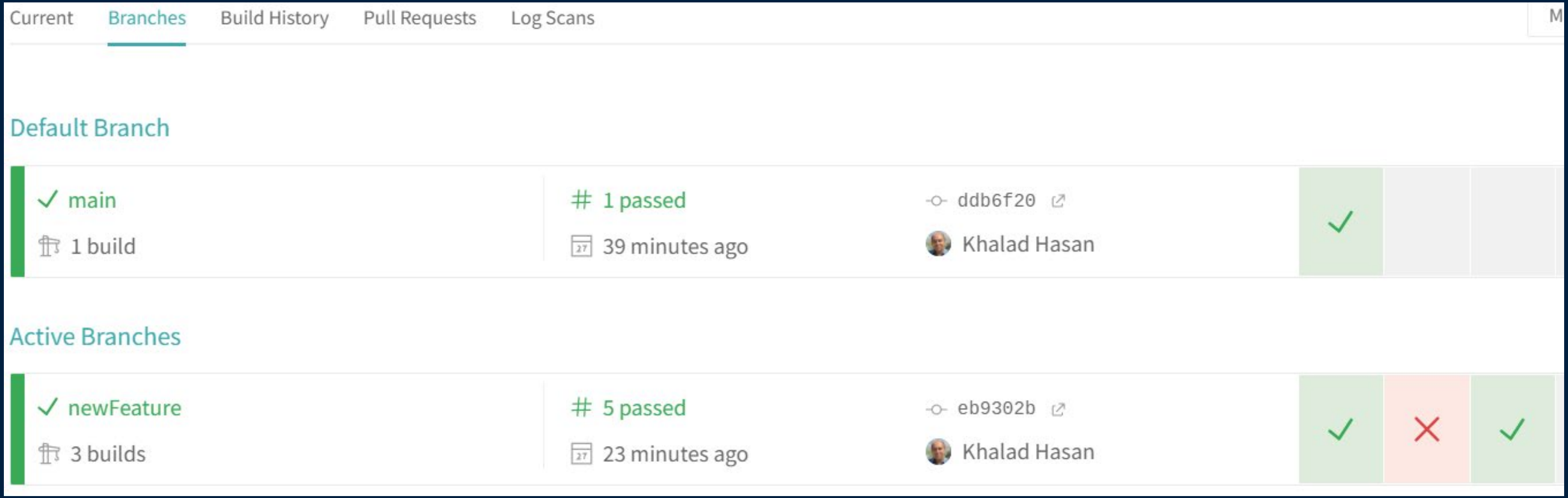


× PR #1 changed from + to * #4 failed
Khalad Hasan a02d401

Travis: Branches

Once we correct the code, the build will be successful.

```
def addition(num1, num2):
    return num1 + num2
```



Default Branch

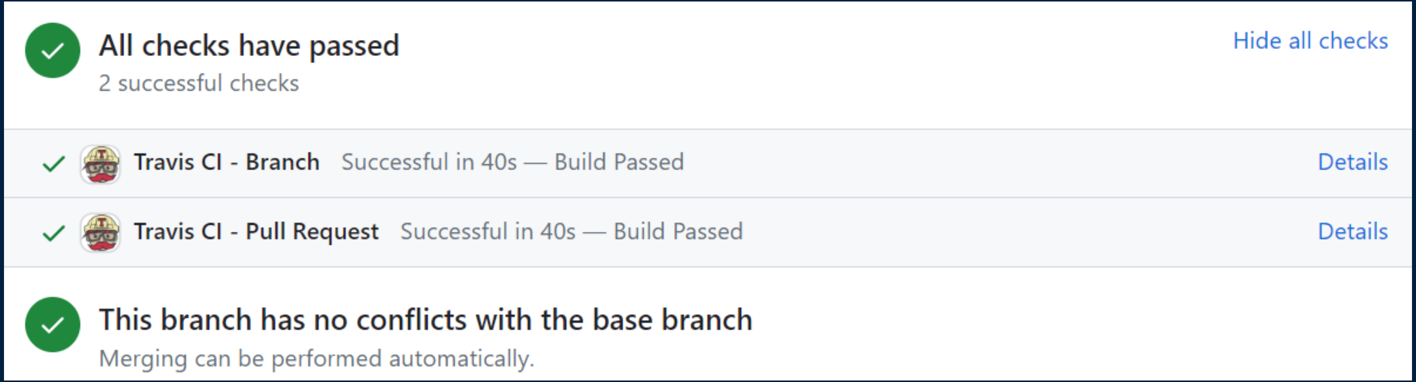
✓ main — 1 build — # 1 passed — 39 minutes ago — ddb6f20 — Khalad Hasan — ✓

Active Branches

✓ newFeature — 3 builds — # 5 passed — 23 minutes ago — eb9302b — Khalad Hasan — ✓ ✗ ✓

Pull Request

Once we change to the correct code:



All checks have passed
2 successful checks

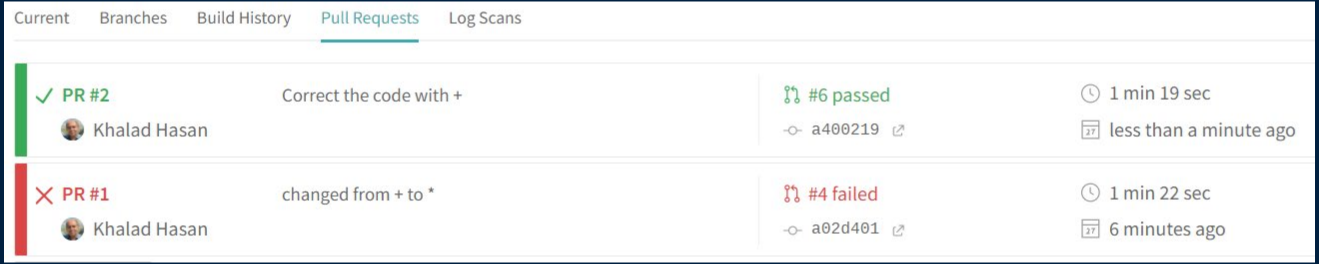
Hide all checks

✓ Travis CI - Branch Successful in 40s — Build Passed Details

✓ Travis CI - Pull Request Successful in 40s — Build Passed Details

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

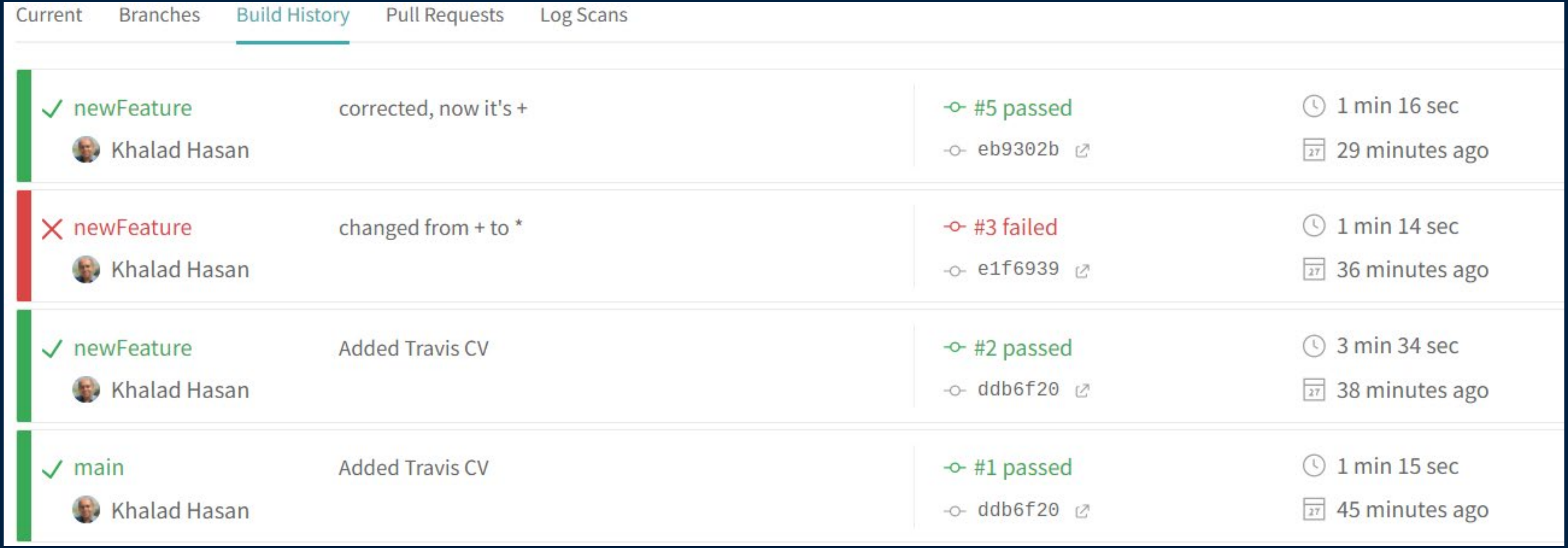
Travis will show the following:



✓ PR #2 Khalad Hasan	Correct the code with +	#6 passed a400219	1 min 19 sec less than a minute ago
✗ PR #1 Khalad Hasan	changed from + to *	#4 failed a02d401	1 min 22 sec 6 minutes ago

Travis: Branches

Build history will show all the pass/fail status



Current | Branches | Build History | Pull Requests | Log Scans

✓	newFeature Khalad Hasan	corrected, now it's +	#5 passed eb9302b	1 min 16 sec 29 minutes ago
✗	newFeature Khalad Hasan	changed from + to *	#3 failed e1f6939	1 min 14 sec 36 minutes ago
✓	newFeature Khalad Hasan	Added Travis CV	#2 passed ddb6f20	3 min 34 sec 38 minutes ago
✓	main Khalad Hasan	Added Travis CV	#1 passed ddb6f20	1 min 15 sec 45 minutes ago

Try it: Travis

Task 1: Create a Github repository called DATA533LEC5. Clone the repo to your local machine.

Task 2: Setup Travis CI to sync the repository

Task 3: Create an application using Python inside the repo to find the maximum value between two numbers

Task 4: Create Unit Tests to check the Python program

Task 5: Define the continuous build in `.travis.yml` file.

Task 6: Push the local repo to Github.

Task 7: Create a new branch, push the branch to the Github and create and manage Pull Requests

Objectives

- Understand different testing techniques
- Learn about black and white box testing
- Learn about code coverage of Python programs
  - Use coverage.py tool for measuring code coverage
- Understand the necessity of Continuous Integration
- Be able to use Travis-CI for Continuous Integration

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