

Sustainable Software Development in an Academic Setting

4th International Symposium on Research and Education of Computational Science (RECS)
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These slides are available under: <https://hartwiganzt.github.io/slides/SustainableSoftwareDevelopment.pdf>

What we cover today

- *Versioning systems*
- *Git workflow*
- *Git hosting sites*
- *Continuous Integration (CI)*
- *GitLab runners*
- *Automated Testing*
- *Unit Testing with GoogleTest*
- *Software Documentation with Doxygen*

To interactively participate in this course, you need a GitLab account.

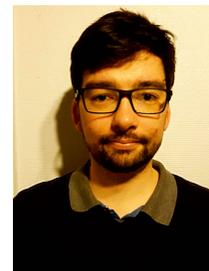
- *Please create an account (choose your name carefully!)*
- *Please log in*
- *<https://gitlab.com/>*



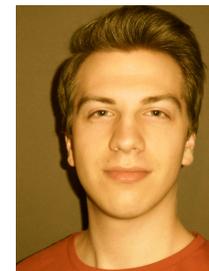
For complete interactive participation (on Linux Systems):

```
apt-get install git cmake g++ gcovr
```

Interactive webinar with the help of



Terry Cojean



Thomas
Grützmacher



Pratik Nayak



Tobias Ribizel



Mike Tsai

What is a version control system?

Version control system for tracking changes in computer files.

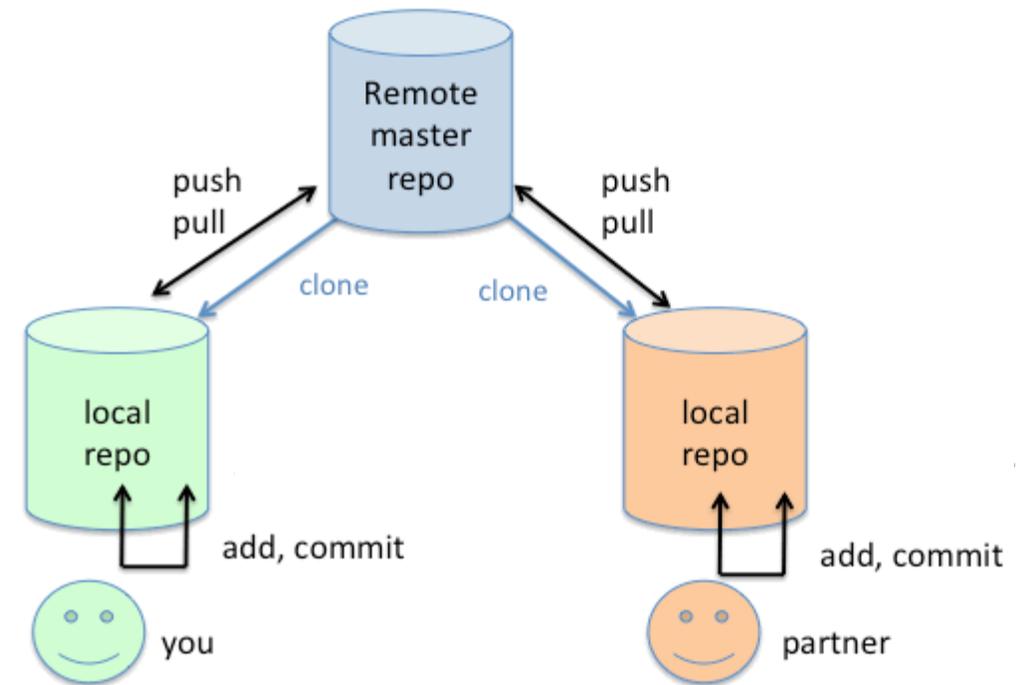
What is a version control system?

Version control system for tracking changes in computer files.



- Distributed version control
- Coordinates work between multiple developers
- Who made what changes and when
- Revert back at any time
- Local and remote repos

- ✓ Keeps track of code history
- ✓ Takes “snapshots” of your files
- ✓ You decide when to take a snapshot by making a “commit”
- ✓ You can visit any snapshot at any time

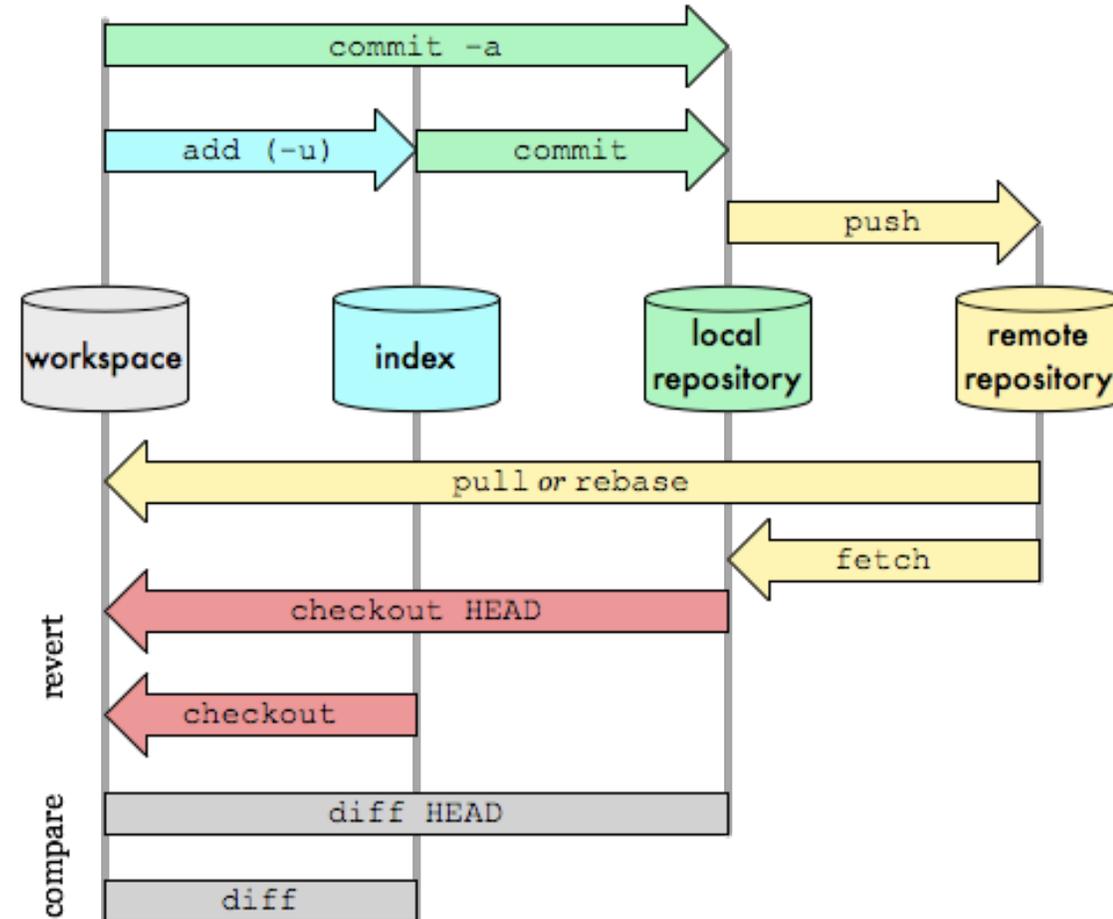


Git Versioning System

- `git init` // Initialize local git repository
- `git add *files` // Add file(s) to snapshot
- `git status` // Check changes not yet in the snapshot
- `git commit *files` // Take snapshot (commit changes)
- `git commit -m 'put a comment on this commit' *files`

Git Data Transport Commands

<http://osteele.com>



Git Cheat Sheet: <https://www.git-tower.com/blog/git-cheat-sheet/>

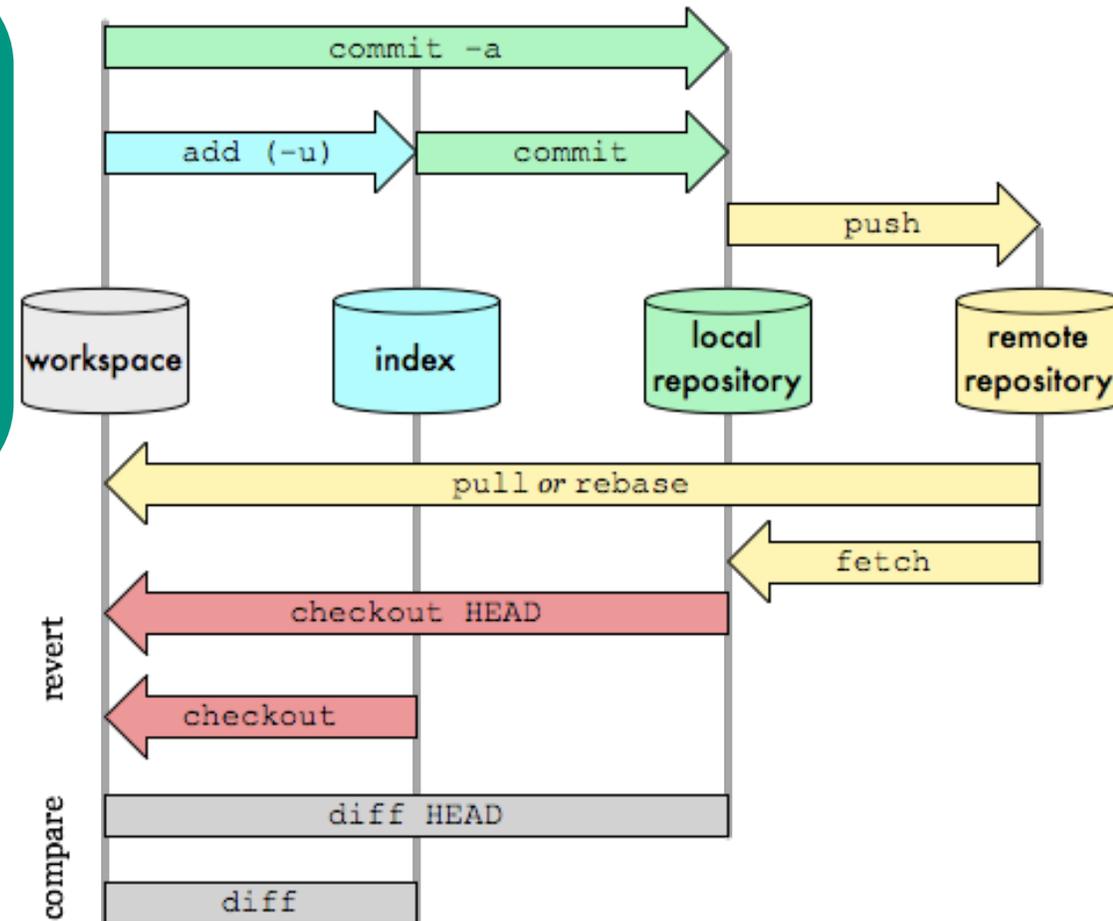
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Local Repository

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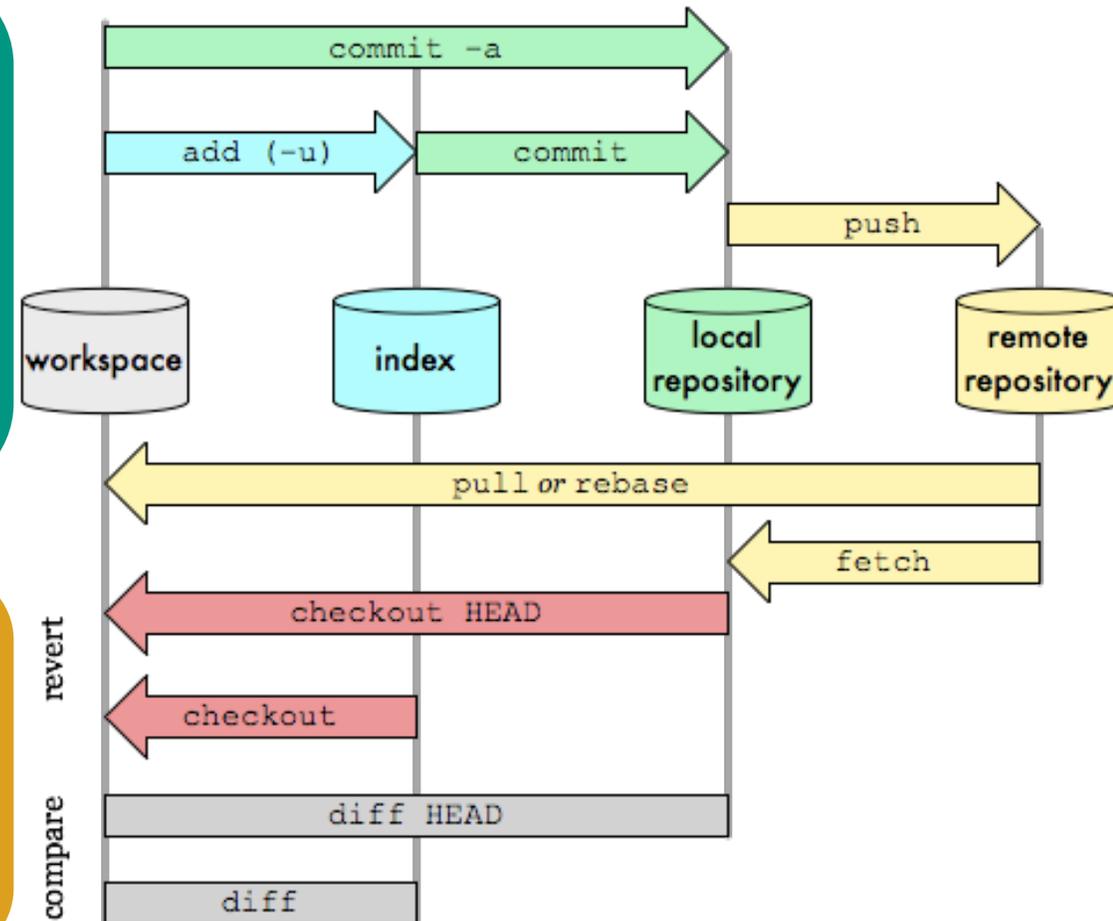
Local Repository

- `git push` // Push local snapshots to remote repo
- `git pull` // Get latest snapshot from remote repo
- `git clone *path/to/repo` // Clone an existing remote repository

Remote Repository

Git Data Transport Commands

<http://osteele.com>

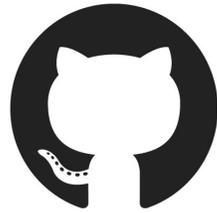


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Git Hosting Sites

They offer the environment for the remote repository.

- GitHub
- GitLab
- Bitbucket
- ...



We may just choose GitLab for this course

- Please create an account (choose your name carefully!)
- Please log in
- <https://gitlab.com/>

https://en.wikipedia.org/wiki/Comparison_of_source-code-hosting_facilities

Name	Code review	Bug tracking	Web hosting	Wiki	Translation system	Shell server	Mailing List	Forum	Personal branch	Private branch	Announce	Build system	Team	Release Binaries	Self-hosting
Assembla	Yes ^[20]	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes ^[21]	Yes	Yes	Yes	Unknown	No
Bitbucket	Yes ^[22]	Yes ^[a]	Yes ^[23]	Yes	No	No	No	No	Yes	Yes ^[b]	No	Yes ^[24]	Yes	No ^[25]	Commercially (BitBucket Server formerly Stash) ^[c]
Buddy	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes ^[d]	Yes	Yes	Yes
CloudForge	Unknown	Yes	Yes	Yes	No	No	No	No	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	No
GitHub	Yes ^[26]	Yes ^{[27][e]}	Yes ^[28]	Yes	No	No	No	No	Yes	Yes	Yes	3rd-party (e.g. Travis CI, Appveyor and others) ^[29]	Yes	Yes	Commercially (GitHub Enterprise)
GitLab	Yes ^[30]	Yes	Yes ^[31]	Yes	No	No	No	No	Yes	Yes	Yes	Yes ^[32]	Yes	Yes ^[33]	Yes ^[f]
GNU Savannah	Yes ^[34]	Yes	Yes	No	No	Yes	Yes	No ^[35]	No	No	Yes	No	Yes	Unknown	Yes

Git Hands-On

1. We create an Account at GitLab and log in.
2. I create a project on GitLab (\git@gitlab.com:hanzt/recs)
3. I add a first source file and make it a public repository
4. You all clone or the project:

```
git clone git@gitlab.com:hanzt/recs
```

5. You add your name to the local version of contributors.txt
6. You check your changes:

```
git diff
```

7. You commit your local changes:

```
git commit -m 'add my name' contributors.txt
```

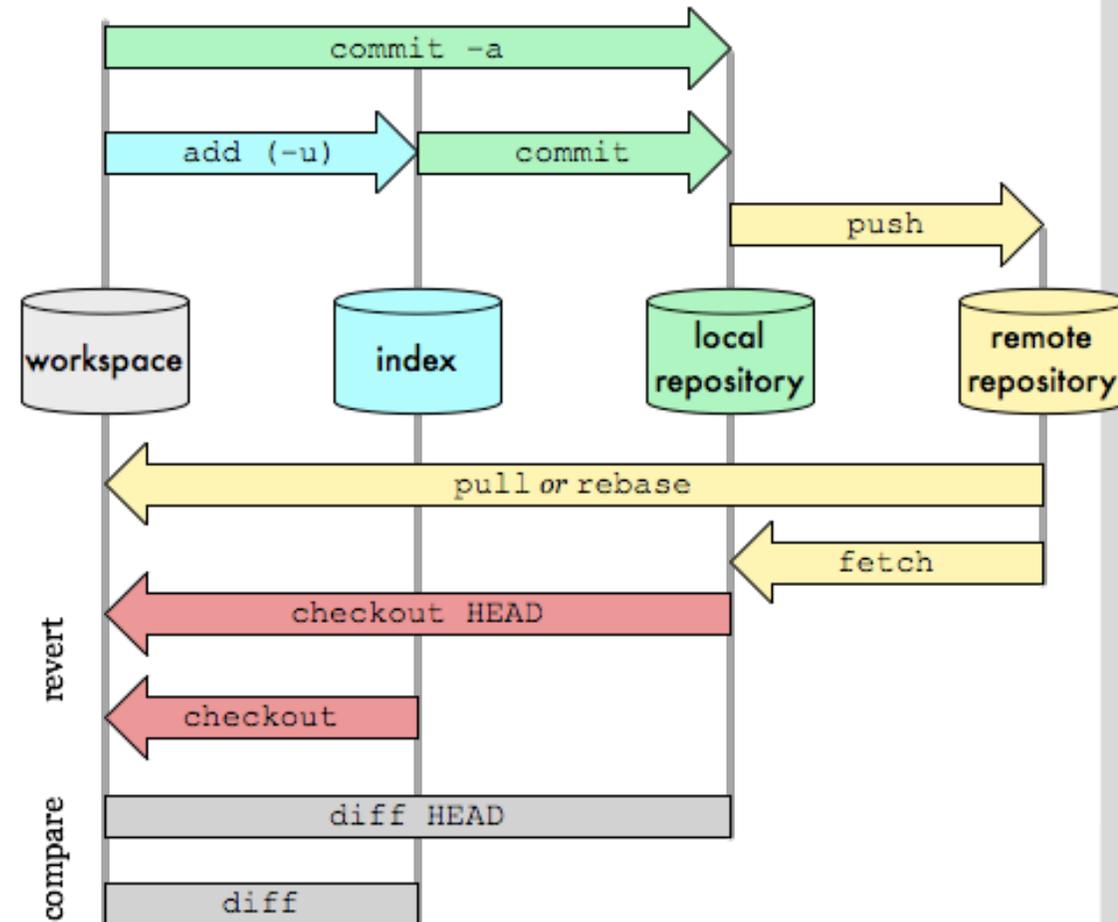
8. You push your local changes to the remote repository:

```
git push origin master
```

9. You fix "merge conflicts"

Git Data Transport Commands

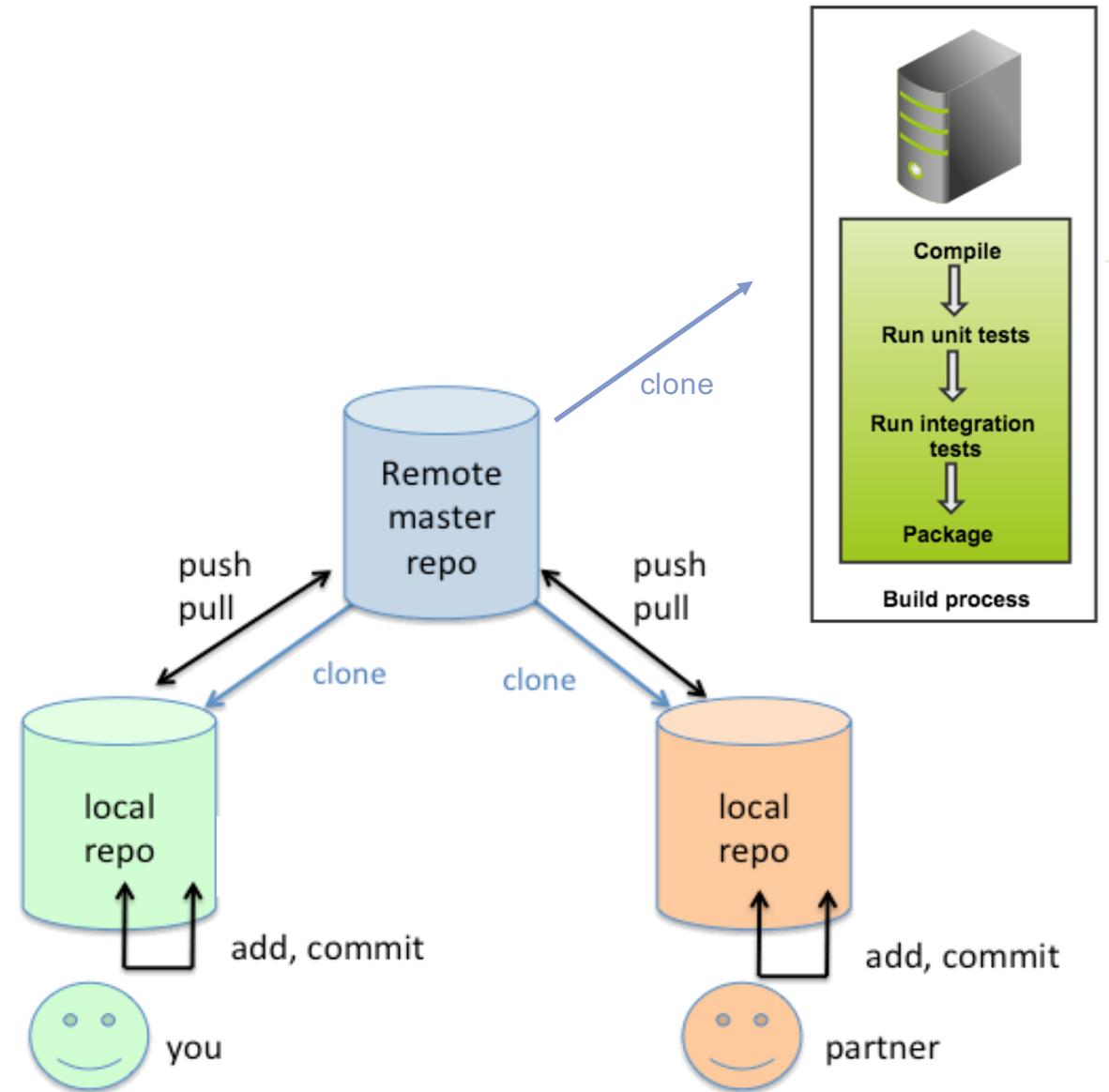
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Continuous Integration (CI)

Sometimes, someone introduces a bug that breaks the code...

- *How do you find out the code is broken?*
- *How do we find out who which code integration introduced the bug?*
- *How can we make sure everything works at any point in time?*



Continuous Integration (CI)

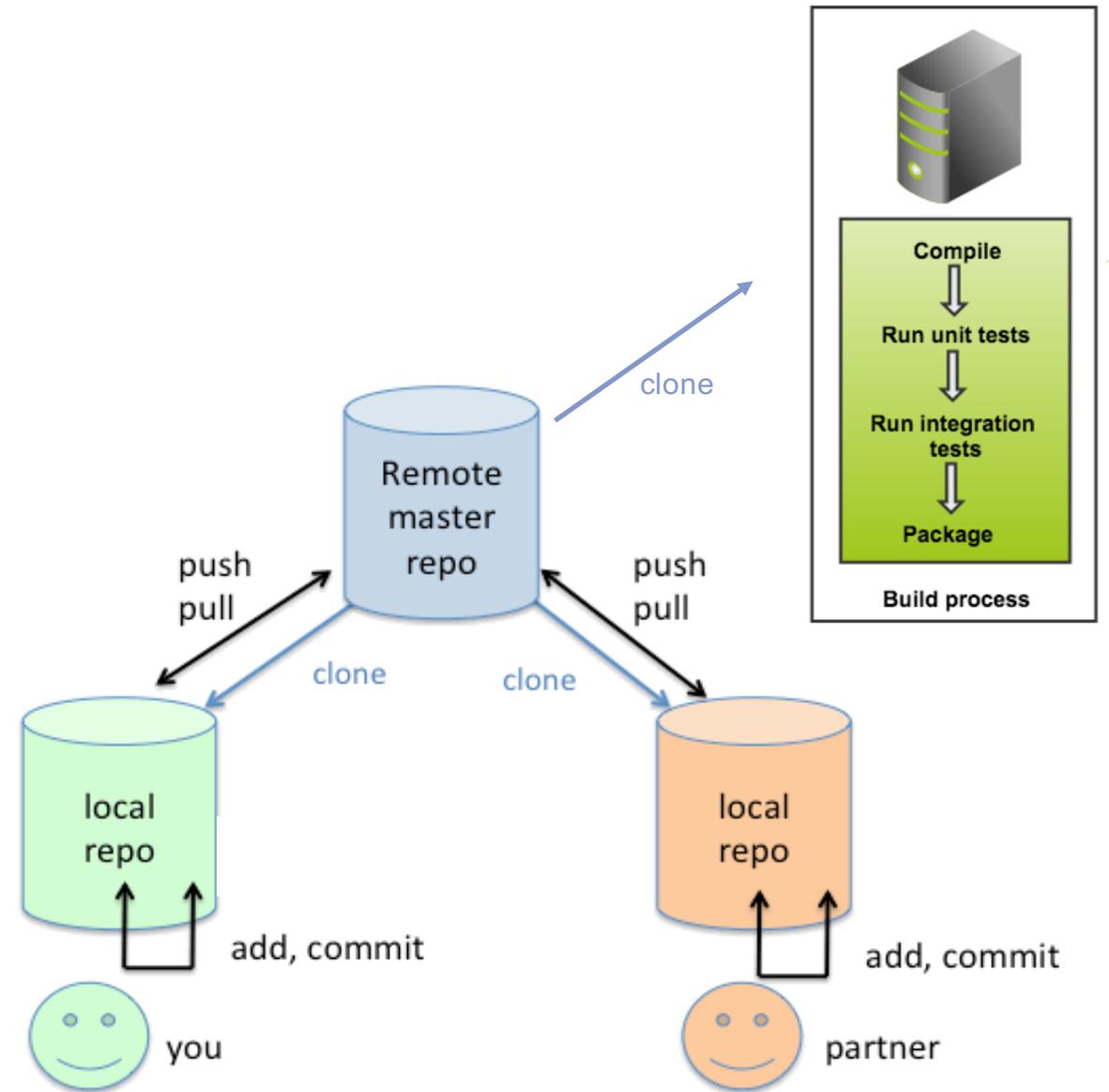
Sometimes, someone introduces a bug that breaks the code...

- *How do you find out the code is broken?*
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- *How can we make sure everything works at any point in time?*

We need a mechanism that constantly checks the functionality of the master "branch".

Continuous Integration

- Sets up a pre-defined environment;
- Clones the remote repository on a server;
- Tries to compile and run all pre-defined tests;
- Reports the outcome;



Continuous Integration on GitLab

- GitLab supports GitLab runners as CI feature.
- They can be configured via adding the file `.gitlab-ci.yml`
<https://docs.gitlab.com/ee/ci/yaml/>
- GitLab runner are set up via web interface.

```
image: ubuntu:14.04

job:
  script:
    - apt-get update
    - apt-get install -y git cmake g++ gcovr
    - git submodule update --init --recursive
    - mkdir build
    - cd build
    - cmake ..
    - make -j
    - gcovr -r ../src/
```

Annotations for the code block:

- Load image of OS (points to `image: ubuntu:14.04`)
- Update OS (points to `apt-get update`)
- Install packages needed: git cmake g++ gcovr (points to `apt-get install -y git cmake g++ gcovr`)
- Create directory (points to `mkdir build`)
- Call CMake (points to `cmake ..`)
- Build library (points to `make -j`)
- gcov checks unit test coverage (points to `gcovr -r ../src/`)

Hartwig Anzt > heksagon_test > Pipelines > #51657453

passed Pipeline #51657453 triggered 24 minutes ago by Hartwig Anzt

example .gitlab-ci.yml

Software Testing

Automated testing:

The practice of writing code to test the code, and then run those tests in an automated fashion.

Production Code



Test Code

Software Testing

Automated testing:

The practice of writing code to test the code, and then run those tests in an automated fashion.

Production Code



Test Code

Many. Easy-to-write. Execute Fast.

Unit tests:

Check the functionality and validity of each building block without its external dependencies.

- Track down bugs

Software Testing

Automated testing:

The practice of writing code to test the code, and then run those tests in an automated fashion.

Production Code



Test Code

Fewer. Dependencies.

Integration tests:

Check the applications functionality with its external dependencies.

- Give more confidence in complex application.
- Tests units/classes as whole.

Many. Easy-to-write. Execute Fast.

Unit tests:

Check the functionality and validity of each building block without its external dependencies.

- Track down bugs

Software Testing

Automated testing:

The practice of writing code to test the code, and then run those tests in an automated fashion.

Production Code



Test Code

Few.
Complex.

End-to-End tests:

Check the applications functionality with its external dependencies and user input.

- Test complete workflow and application interaction.
- Very slow and brittle.

Fewer. Dependencies.

Integration tests:

Check the applications functionality with its external dependencies.

- Give more confidence in complex application.
- Tests units/classes as whole.

Many. Easy-to-write. Execute Fast.

Unit tests:

Check the functionality and validity of each building block without its external dependencies.

- Track down bugs

Unit tests with Googletest



- Framework to facilitate unit testing.
- <https://github.com/google/googletest>

Let's do an example.

Much of this material is taken from **Nikolaos Pothitos**

<http://cgi.di.uoa.gr/~pothitos/>

<https://github.com/pothitos/gtest-demo-gitlab>

```
[=====] Running 1 test from 1 test case.
[-----] Global test environment set-up.
[-----] 1 test from AddTest
[ RUN    ] AddTest.TwoAndTwo
test2.cc:6: Failure
           Expected: Add(2, 2)
           Which is: 4
To be equal to: 5
[  FAILED ] AddTest.TwoAndTwo (0 ms)
[-----] 1 test from AddTest (0 ms total)

[-----] Global test environment tear-down
[=====] 1 test from 1 test case ran. (1 ms total)
[  PASSED ] 0 tests.
[  FAILED ] 1 test, listed below:
[  FAILED ] AddTest.TwoAndTwo

1 FAILED TEST
```

Software Documentation

Doxygen is the de facto standard tool for generating documentation from annotated C++ sources, but it also supports other popular programming languages such as C, Objective-C, C#, PHP, Java, Python, IDL (Corba, Microsoft, and UNO/OpenOffice flavors), Fortran, VHDL, Tcl, and to some extent D.

- Automated code documentation tool.
- Converts comments in source code into documentation.
- HTML-oriented.
- <http://www.doxygen.nl/>
- <https://github.com/doxygen/doxygen.git>

My Project

Main Page	Classes	Files	Search
Class List	Class Index	Class Members	
Foo >	Foo >		

Public Types | List of all members

Foo::Foo Class Reference

Public Types

enum **Foo**
Foo enum, possible ways to foo.

The documentation for this class was generated from the following file:

- **Foo.h**

Generated on Thu Dec 6 2012 15:38:12 for My Project by  1.8.2



Example:

<https://www.dealii.org/current/doxygen/deal.II/classTorusManifold.html>

References & Further Reading



<https://bssw.io/>

- <https://www.git-tower.com/blog/git-cheat-sheet/>
- <https://github.com/google/googletest>
- <https://github.com/pothitos/gtest-demo-gitlab>
- <https://docs.gitlab.com/ee/ci/yaml/>
- <http://www.doxygen.nl/>

Better Scientific Software (BSSw)

Scientific software has emerged as an essential discipline in its own right. Because computational models, computer architectures, and scientific software projects have become extremely complex, the Computational Science & Engineering (CSE) community now has a unique opportunity—and an implicit mandate—to address pressing challenges in scientific software productivity, quality, and sustainability.

GET ORIENTED

Communities Overview

Site Overview

Intro to CSE

Intro to HPC

These slides are available under: <https://hartwiganzt.github.io/slides/SustainableSoftwareDevelopment.pdf>