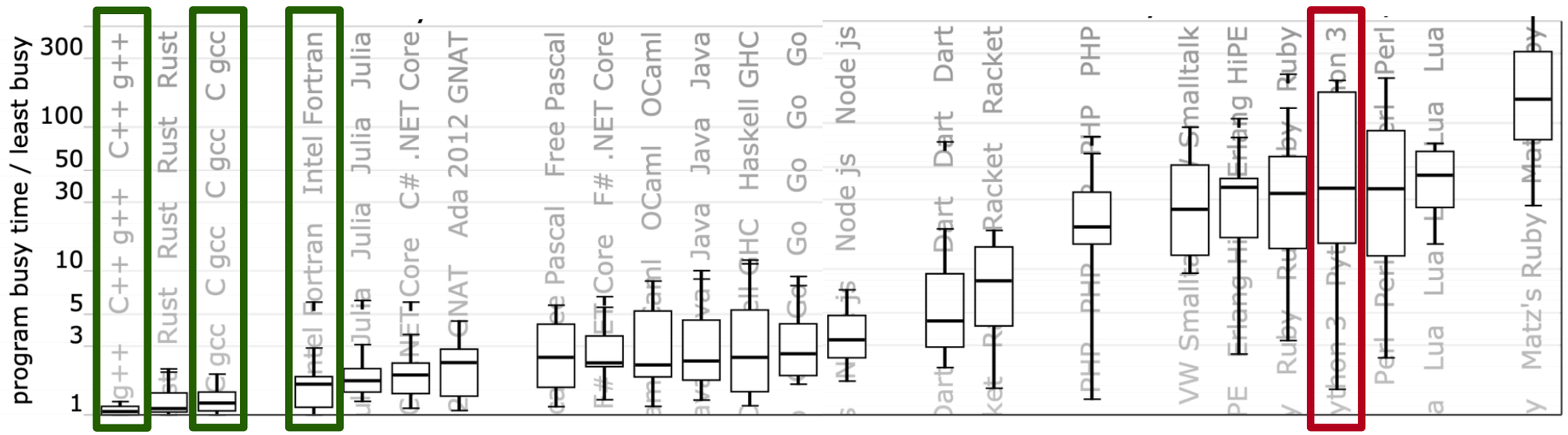
TUTORIAL #1
PYTHON & GIT
For Lab Assignments

Outline

- Python & Numpy for scientific programming
- Git for version control & codes management
- Lab workflow involving GitLab

Python

- General programming language
- Easy to learn/code, but slow to execute

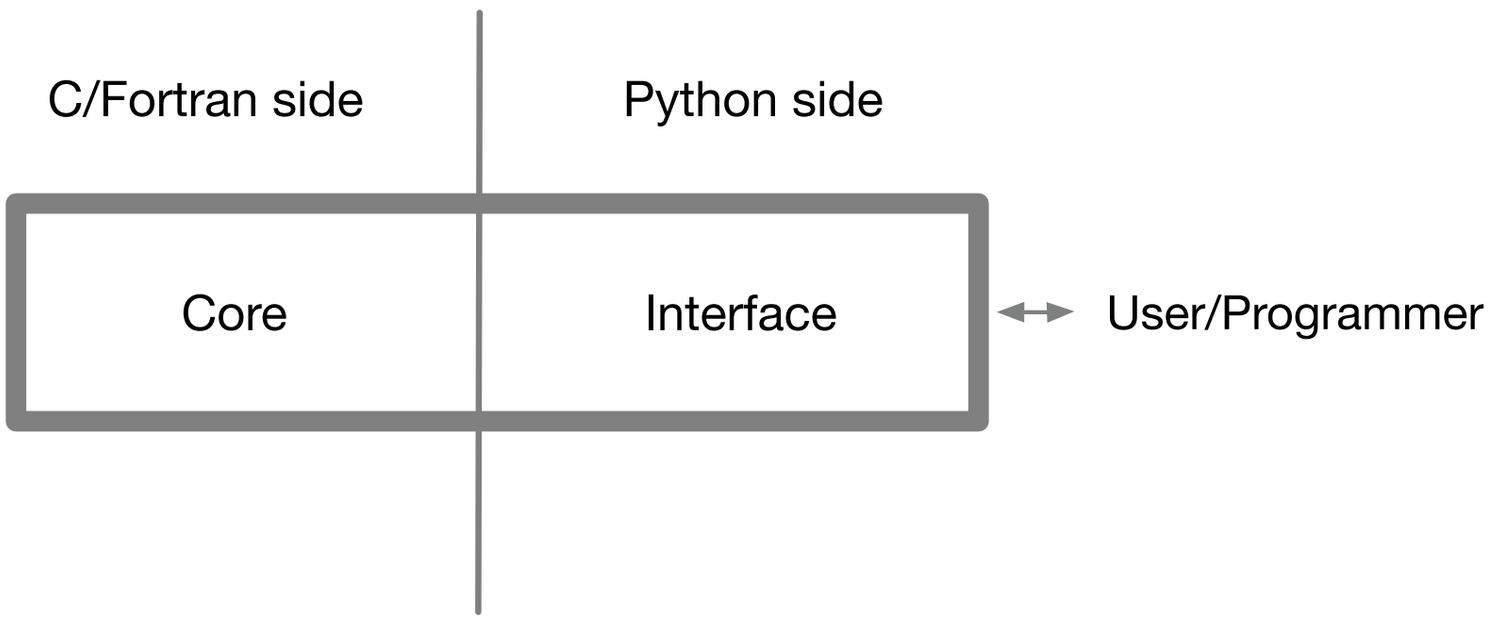


- Can be ported to faster languages

NumPy

Python library for efficient arithmetics

- Collection of high-level math functions
- And tensor/matrix utilities
- Mostly written in C/Fortran (fast execution)
- Interfaced to Python (easy coding)



```python
import numpy as np

A = np.random.randn(5,4)
print(A)

U,s,VT = np.linalg.svd(A)
print(U)
print(s)
print(VT)

print(U.T @ U)

print(VT @ VT.T)
```

```
[[-2.56102287  0.72436197 -1.38172136 -0.38375155]
 [-0.23937204  1.93000121 -0.27333143 -0.00326422]
 [-0.02064856  0.70383091  0.03910733 -0.1307488 ]
 [-1.09124229  0.30844582  0.0302325  -0.36863731]
 [ 1.73384113 -0.1072562  -0.08283792  0.51137614]]
```

```
[[-0.80406743  0.12300326  0.57123922  0.10583502 -0.02881774]
 [-0.2599682  -0.88409729 -0.1046106  -0.37166181  0.04138416]
 [-0.07377353 -0.32536621 -0.20851188  0.84355955 -0.36554668]
 [-0.30089959  0.07691478 -0.44438178  0.24218206  0.8046218 ]
 [ 0.43578549 -0.30242872  0.64945363  0.28358699  0.46520563]]

[3.69103406 1.93464697 0.91823979 0.10192123]

[[ 0.86884181 -0.34560798  0.30722367  0.17686904]
 [-0.36438879 -0.92525994  0.04463296 -0.09551306]
 [ 0.19316003 -0.15420522 -0.91053402  0.33141779]
 [ 0.27390496 -0.02588274 -0.2730372  -0.92182257]]
```

```
[[ 1.00000000e+00 -4.99022374e-17  8.25644396e-17 -8.80535455e-17
   2.27370356e-16]
 [-4.99022374e-17  1.00000000e+00 -2.56422322e-16 -7.27333411e-17
   2.09318332e-16]
 [ 8.25644396e-17 -2.56422322e-16  1.00000000e+00 -1.58944721e-16
   9.60003726e-17]
 [-8.80535455e-17 -7.27333411e-17 -1.58944721e-16  1.00000000e+00
   2.91083738e-17]
 [ 2.27370356e-16  2.09318332e-16  9.60003726e-17  2.91083738e-17
   1.00000000e+00]]
```

```
[[ 1.00000000e+00  0.00000000e+00 -2.77555756e-17  2.77555756e-17]
 [ 0.00000000e+00  1.00000000e+00 -3.88578059e-16  0.00000000e+00]
 [-2.77555756e-17 -3.88578059e-16  1.00000000e+00 -2.77555756e-17]
 [ 2.77555756e-17  0.00000000e+00 -2.77555756e-17  1.00000000e+00]]
```

NumPy

Some useful features and functions

- Create vector/matrix/tensor

```
np.zeros(4,2,3)
np.ones(4)
np.random.randn(2,4)
np.array([
  [1,0,0],
  [0,1,0],
  [0,0,1],])
np.eye(3)
np.diag([1,1,1])
```

- Arithmetics

```
A+B
A-1
A*B
A@B
A/B
A**2
```

- Indexing

```
X[:,0]
X[0]
X[0,-1]
X[:,1:3]
X[-2:,:2]
```

- Linear algebra

```
np.linalg.svd(A)
np.linalg.eigh(A)
np.linalg.inv(A)
np.linalg.matrix_rank(A)
np.linalg.norm(A)
```

- Tensor properties/utils

```
A.shape
A.reshape(…)
A.mean(…)
A.sum(…)
```

C.f. https://numpy.org/doc/stable/reference/index.html

Python IDEs

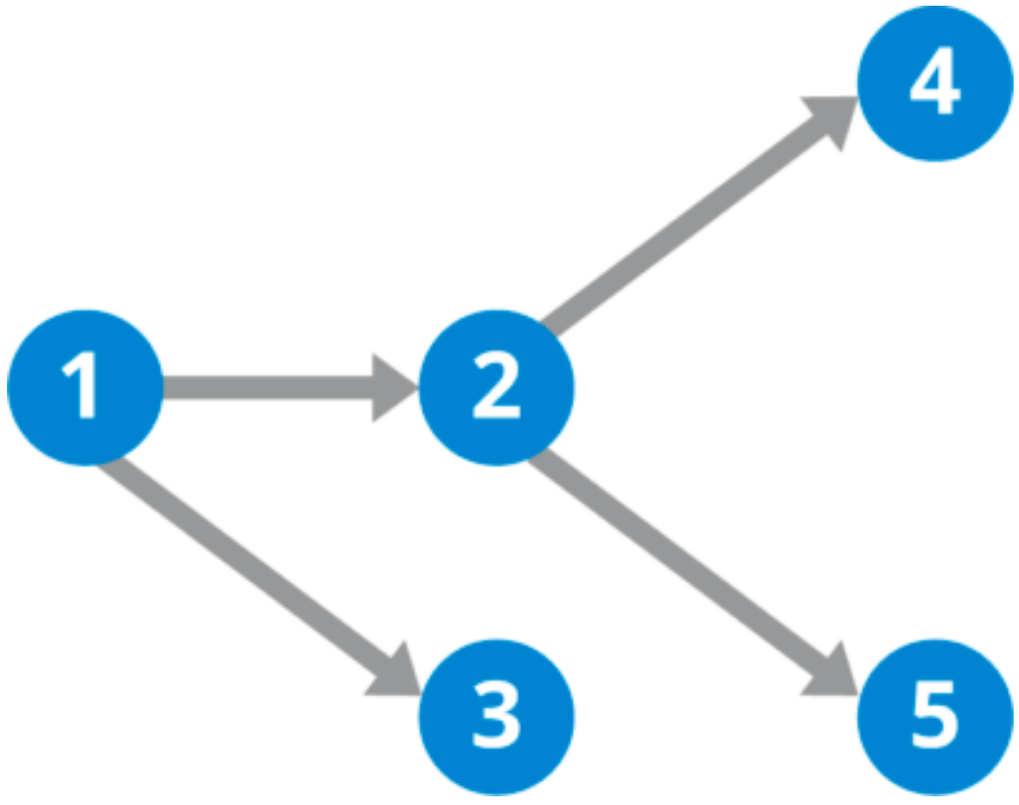
Edit, run, debug and more…

- VSCode (https://code.visualstudio.com/)
- Pycharm (https://www.jetbrains.com/pycharm/)
- Spyder (https://www.spyder-ide.org/)

Git

- Codes version control tools
- Easy management of multiple versions
  - Backup/restore
  - Jump between
  - Compare
- Can back-up/download projects from cloud (e.g. GitLab)

Directed Acyclic Graph (DAG)

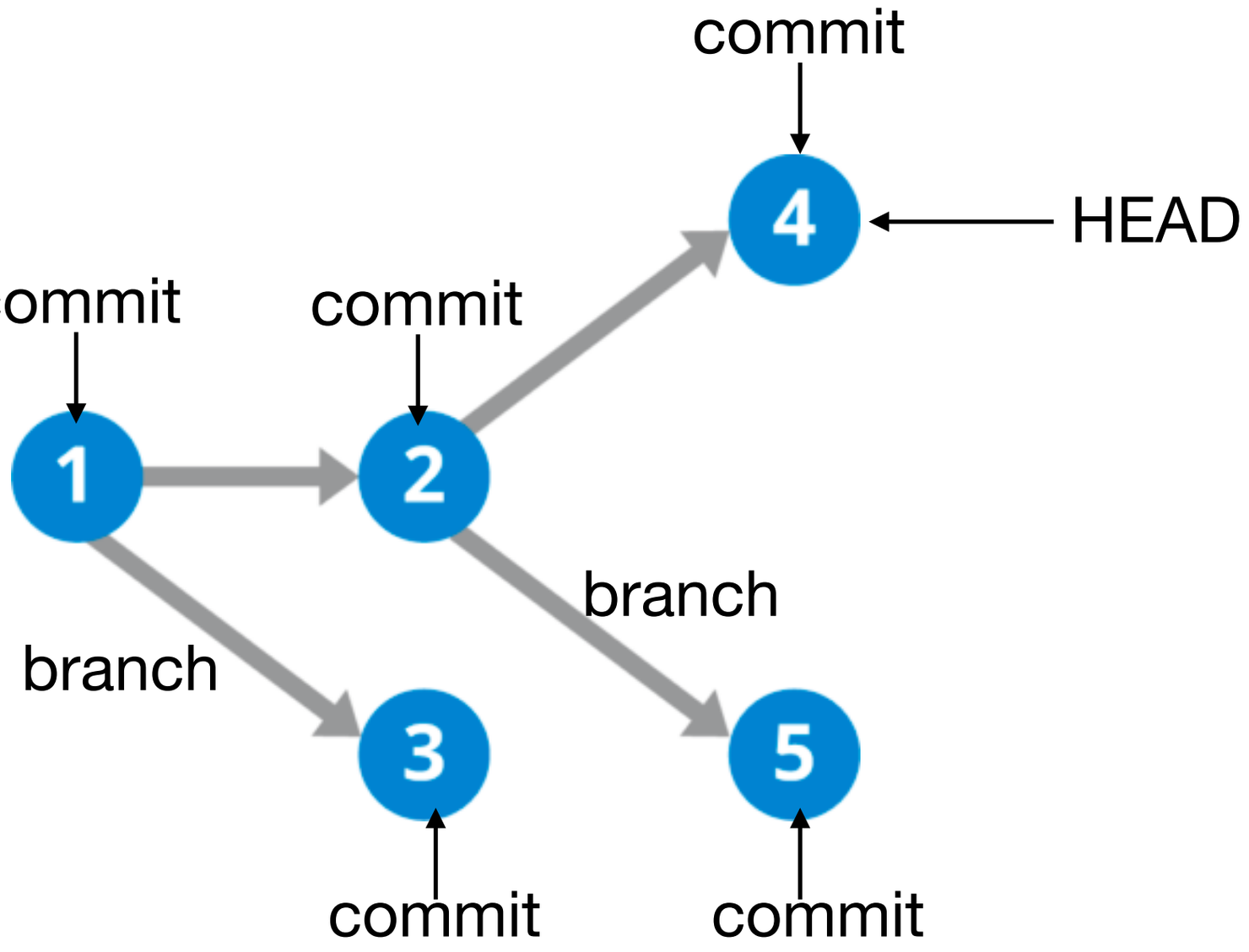


How Git works

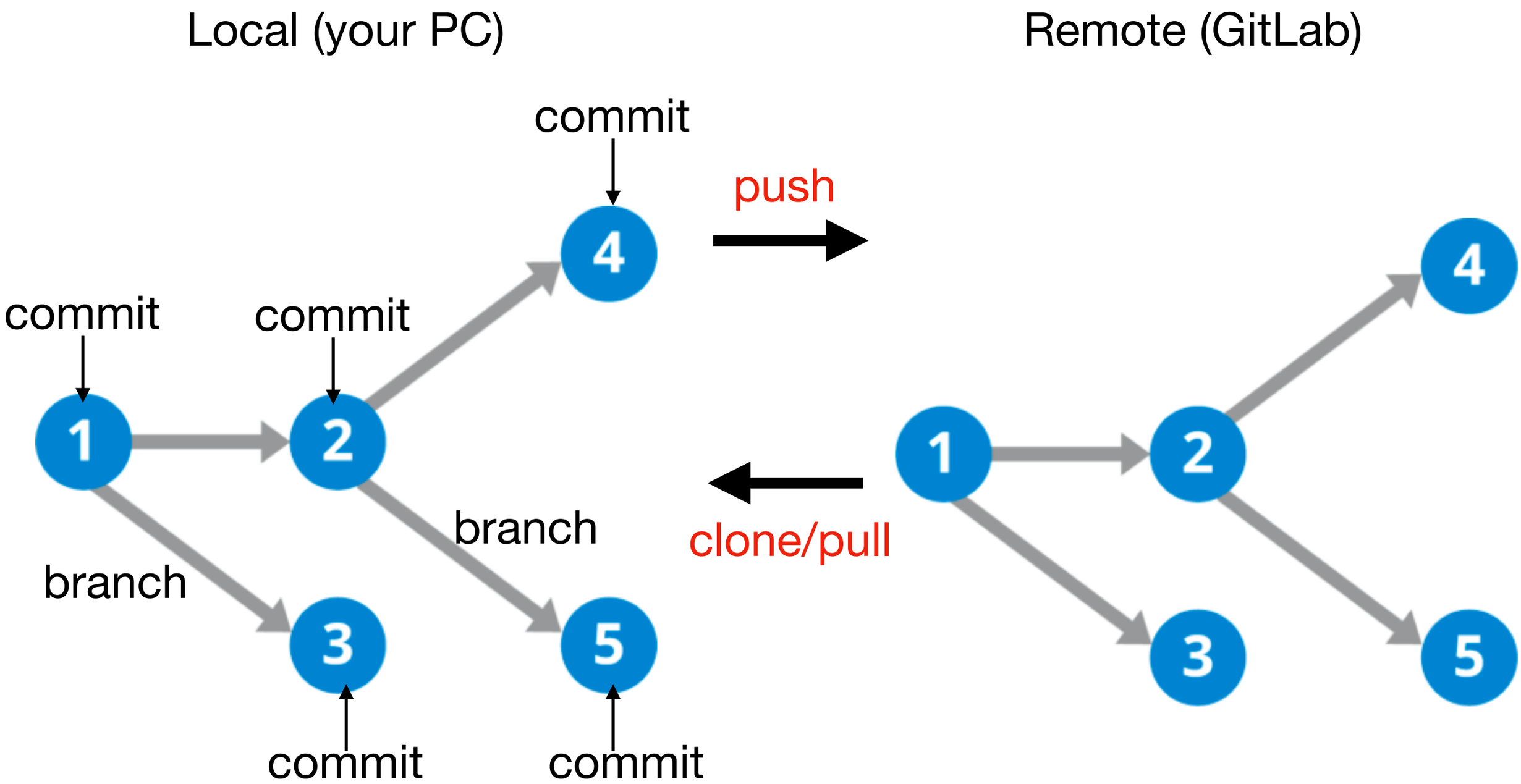
In a nutshell

- Manages files in a folder (**project/repository**) as a DAG
- User can ask git to create a snapshot of files (**commit**)
    - Git tracks changes since last commit and store them
    - User can jump between commits
- User can sync projects from/to a cloud server (**remote**)

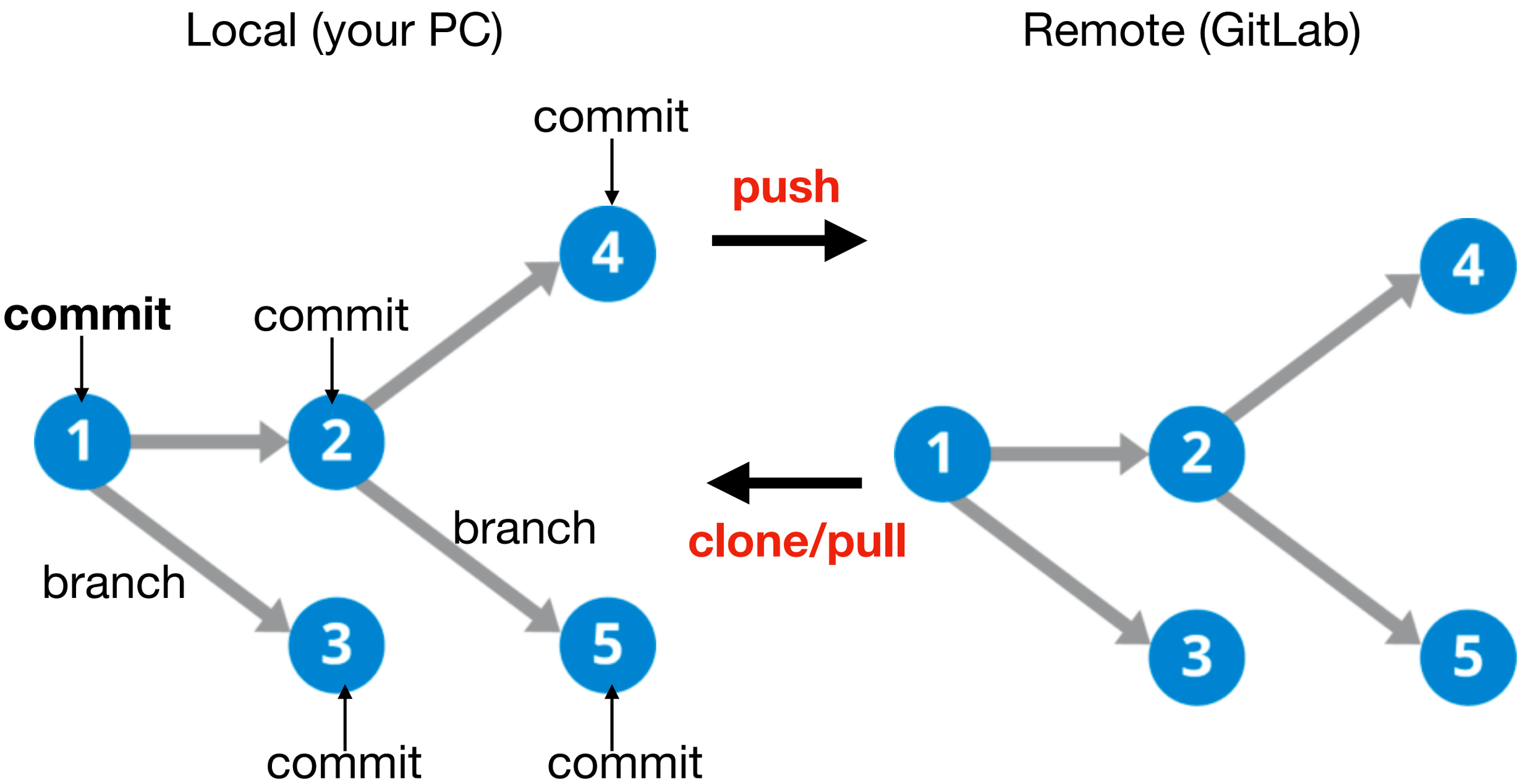
Git as DAG


commit
4
HEAD
commit
commit
1
2
branch
branch
3
5
commit
commit

Git with remote

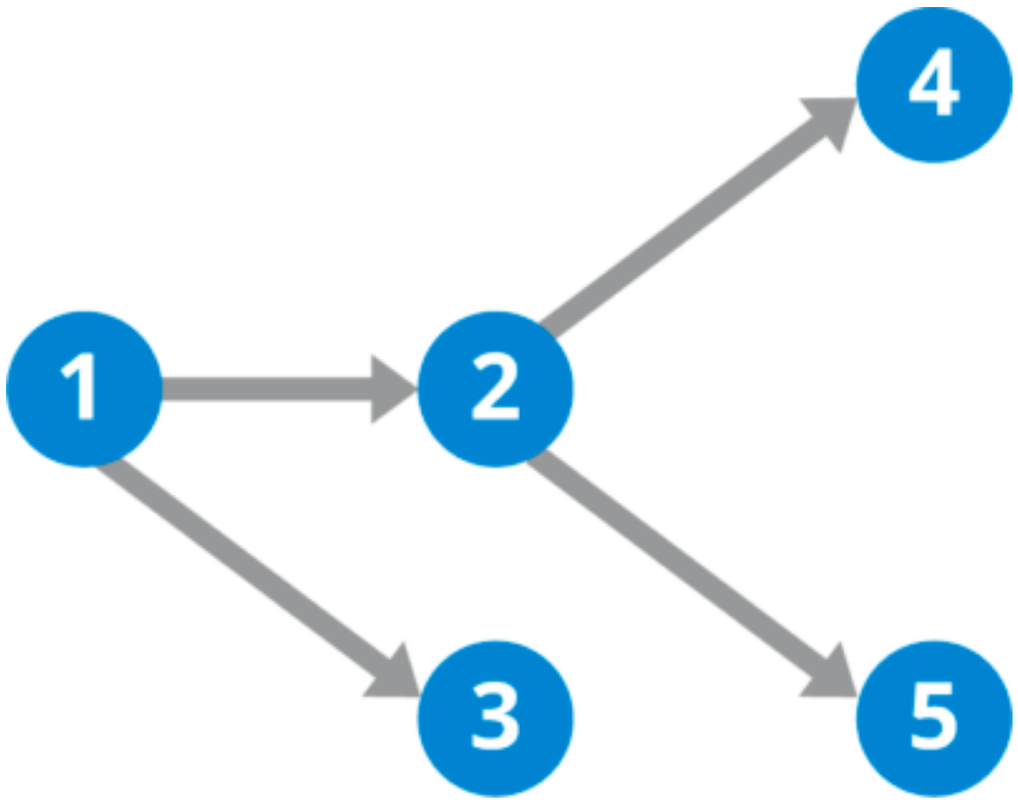


Git with remote



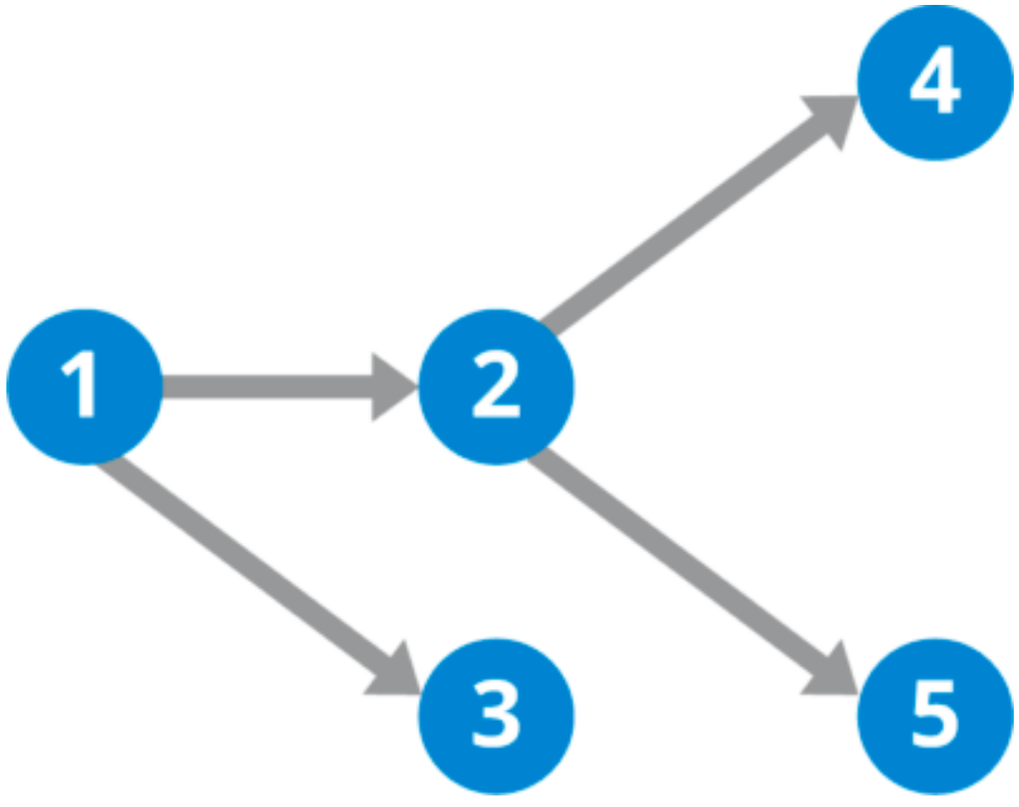
Git with remote

Remote
(Someone else's project)



fork

Remote
(Your copy)

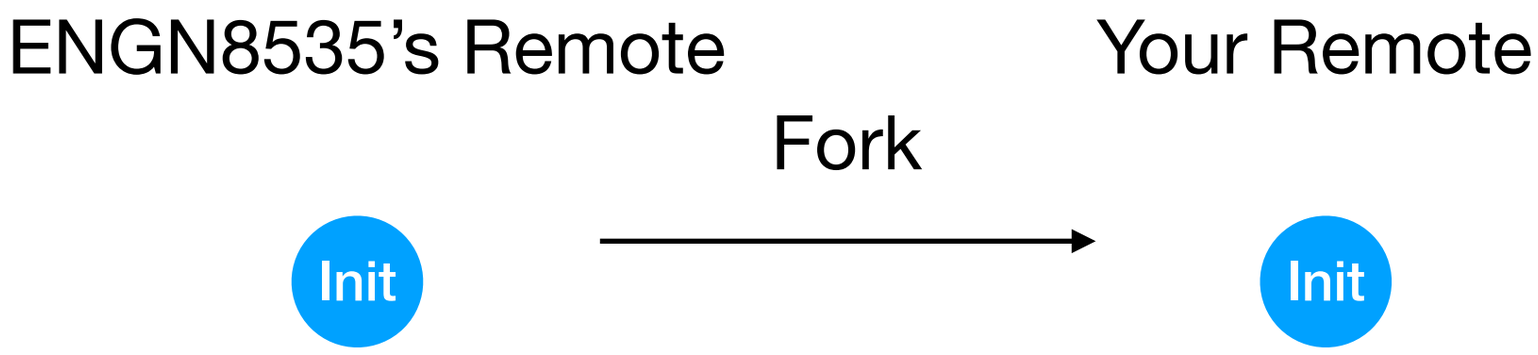


Coding Labs

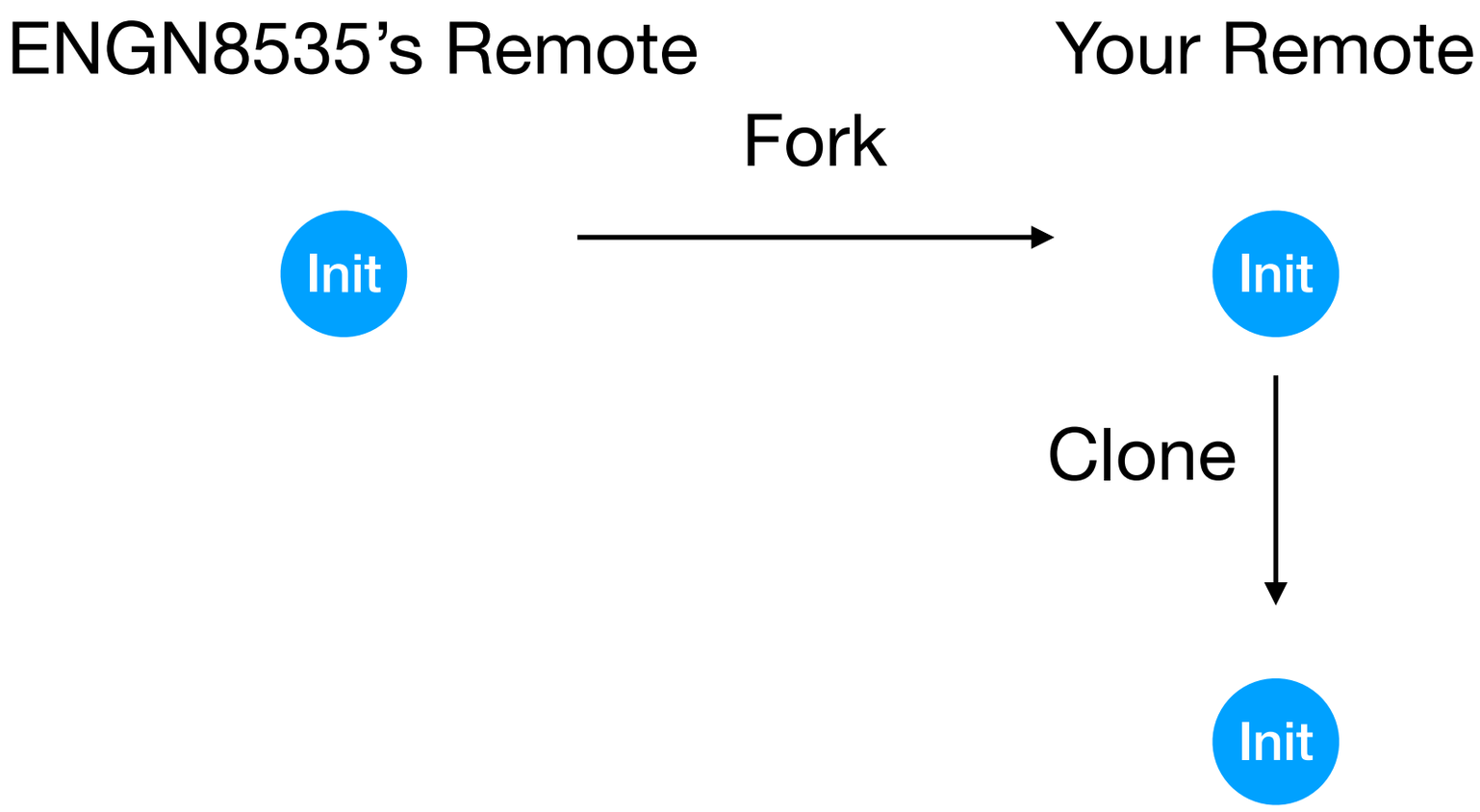
4x7.5 marks (30% of total marks)

- Use your knowledge to complete skeleton codes with Python+Numpy
- All assignments hand-out/submit through GitLab
- All assignments are automatically marked with instant feedback
- GitLab links
  - https://gitlab.cecs.anu.edu.au/engn8535/2021-s1-lab-1
  - https://gitlab.cecs.anu.edu.au/engn8535/2021-s1-lab-2
  - https://gitlab.cecs.anu.edu.au/engn8535/2021-s1-lab-3
  - https://gitlab.cecs.anu.edu.au/engn8535/2021-s1-lab-4

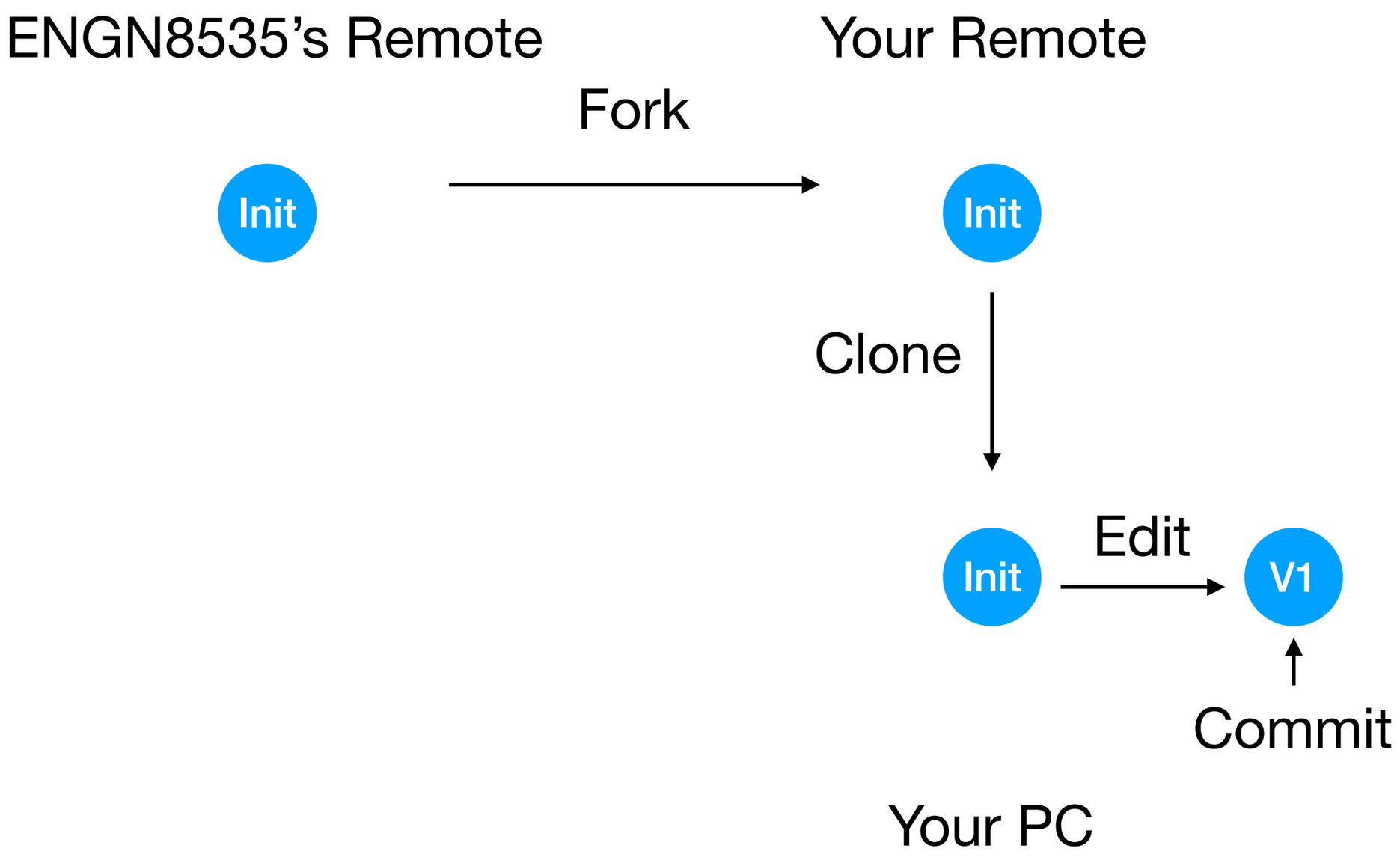
Coding Labs Workflow



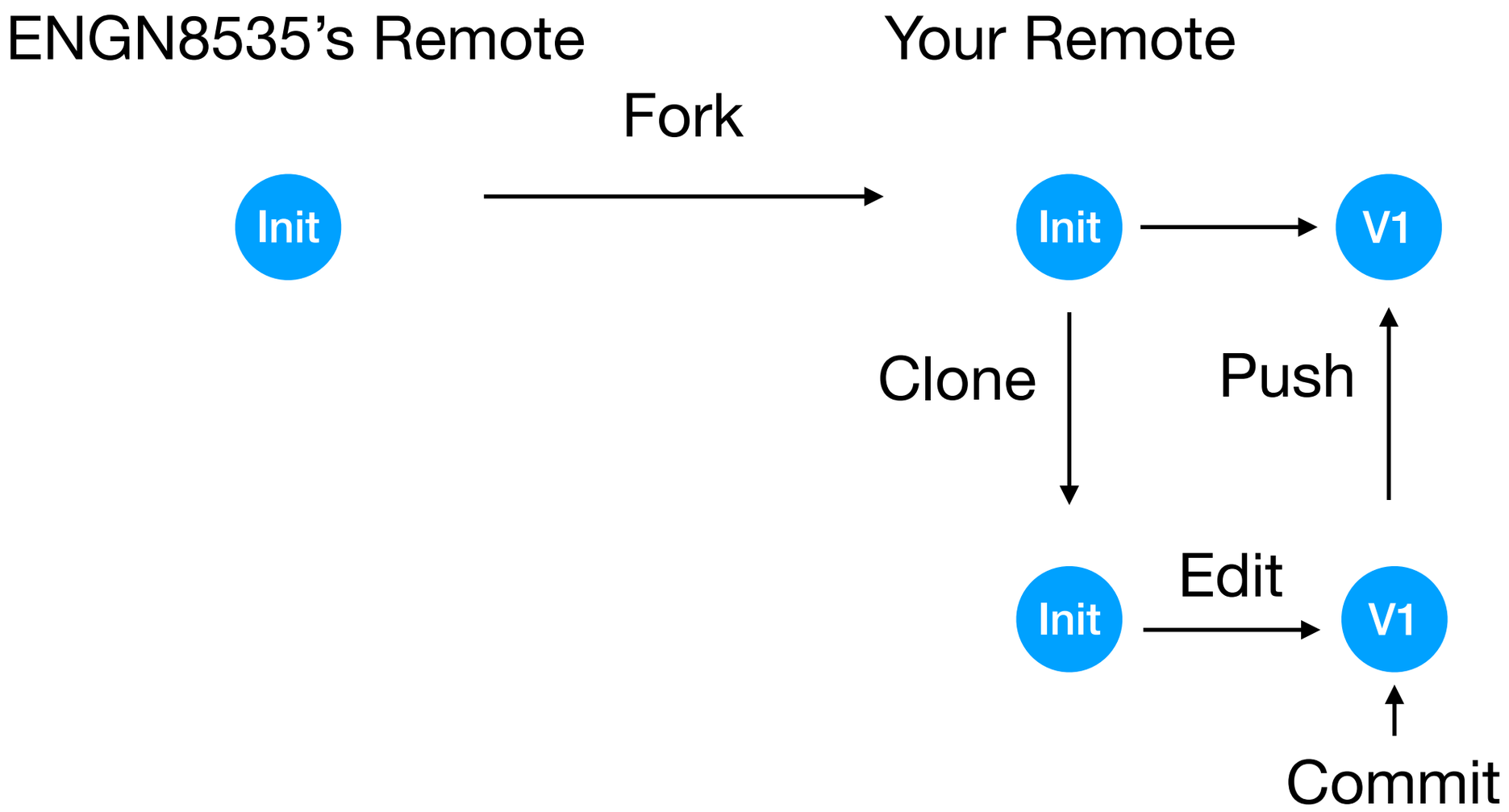
Coding Labs Workflow



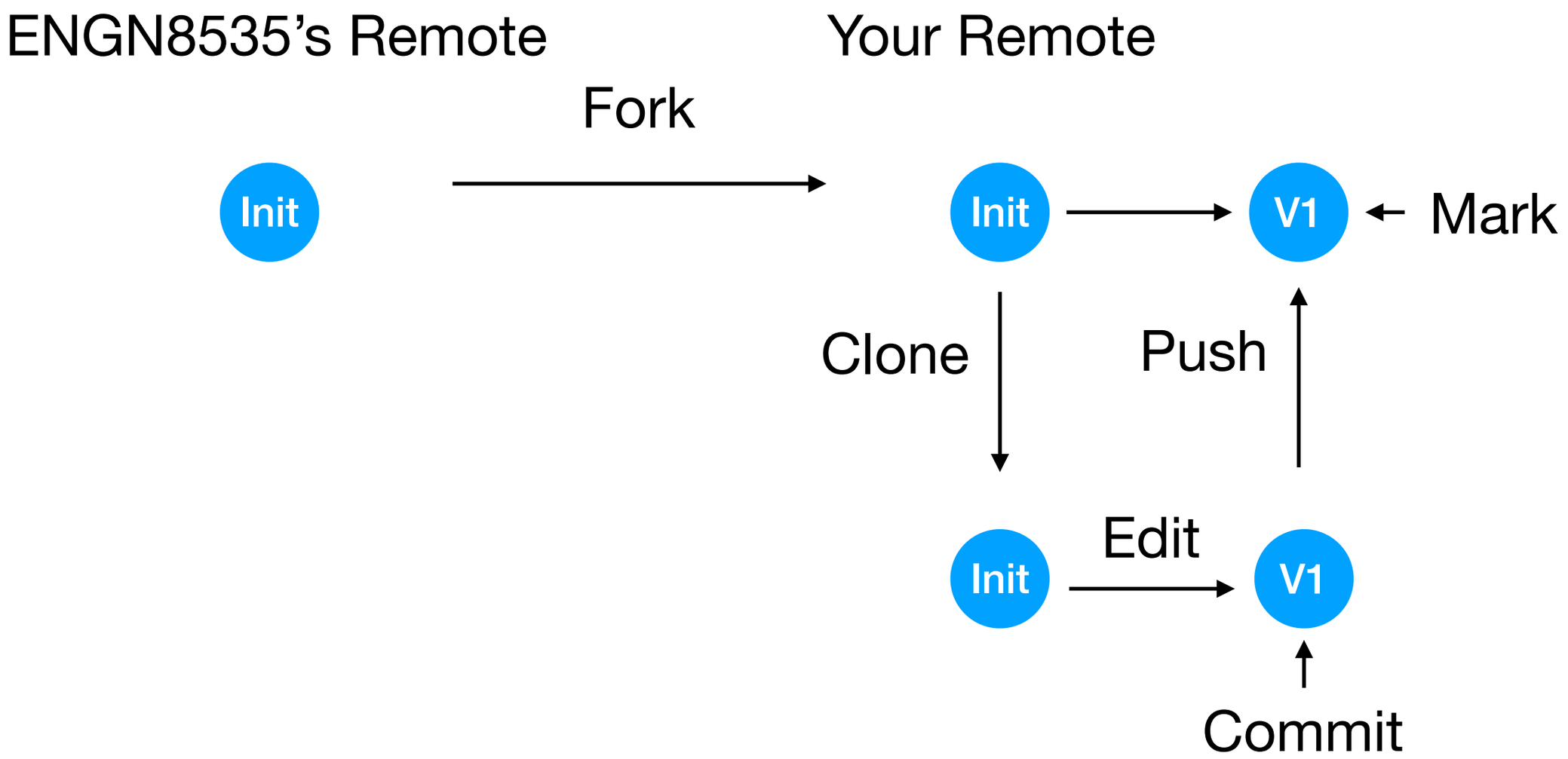
Coding Labs Workflow



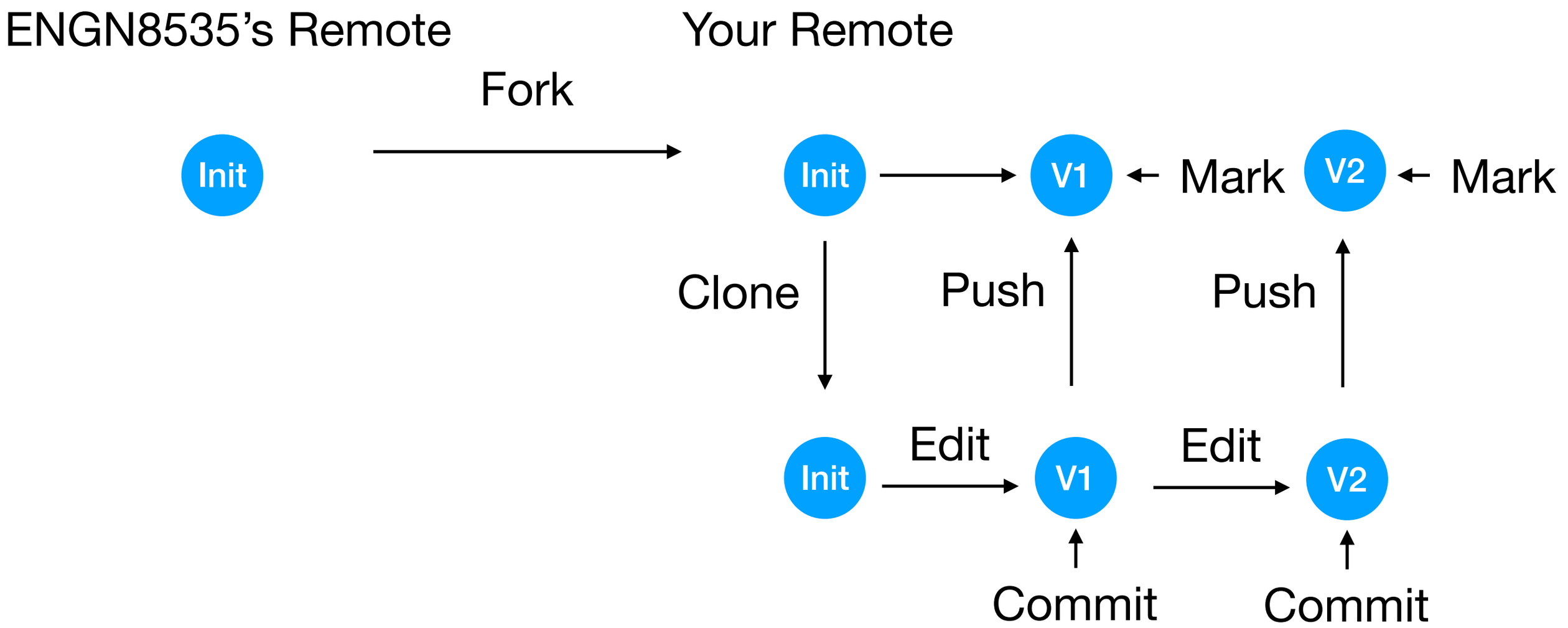
Coding Labs Workflow



Coding Labs Workflow



Coding Labs Workflow



Common reasons for loss of marks

- Feasibility: your answer does not satisfy the constraints
- Optimality: your answer is not the optimal solution
- Efficiency: your program takes too long to run