Introduction to Git for Version Control

This tutorial is aimed at Data Scientists and Statisticians

Presented by: Pavan Datta

Outline of Topics

1. What is Git? Why use Git?

- A open source distributed version control system (DVCS)
    - Source code is available on a **remote repository** (GitHub / GitLab)
    - Source code can be **cloned** onto numerous **local repositories**
- Lightweight, fast, and flexible
    - Most operations are performed **locally**
    - Git only stores **differences** between **commits**
    - Easily context switch between **branches**
    - Easily manage changes to files across large teams
    - Git keeps track of **every** change ever made
- Multiple backups are supported
- Many different workflow styles supported

1. What is GitHub? Why use GitHub?

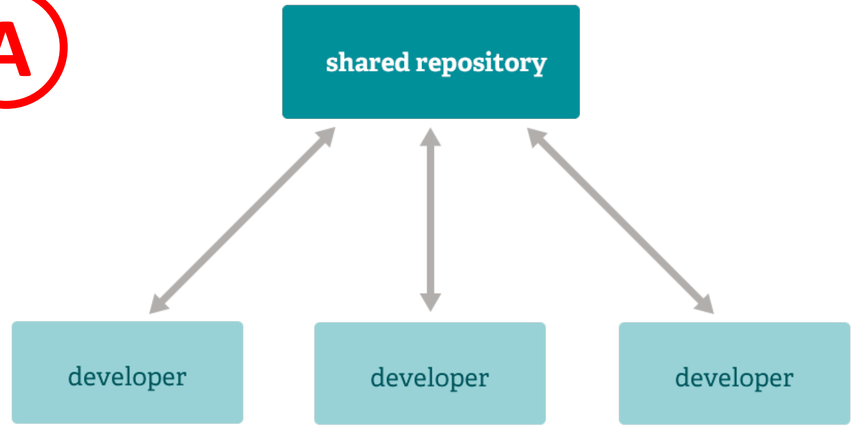
- GitHub is like Facebook, but for hosting code
  - With the right permissions, code sharing and collaboration are possible
  - Many R-packages are now available via GitHub
- GitHub makes code collaborating easier than before
- Supports many different workflow styles
- Let’s check it out!

1. Flexible Workflow Styles Supported by Git

- A Subversion (SVN) style workflow
- B Integration Manager Workflow
- C Dictator and Lieutenants Workflow

1. Flexible Workflow Styles Supported by Git

A



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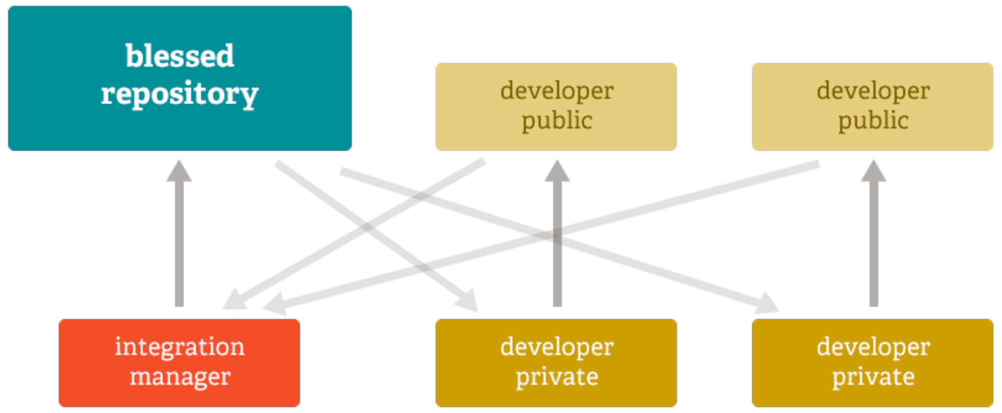

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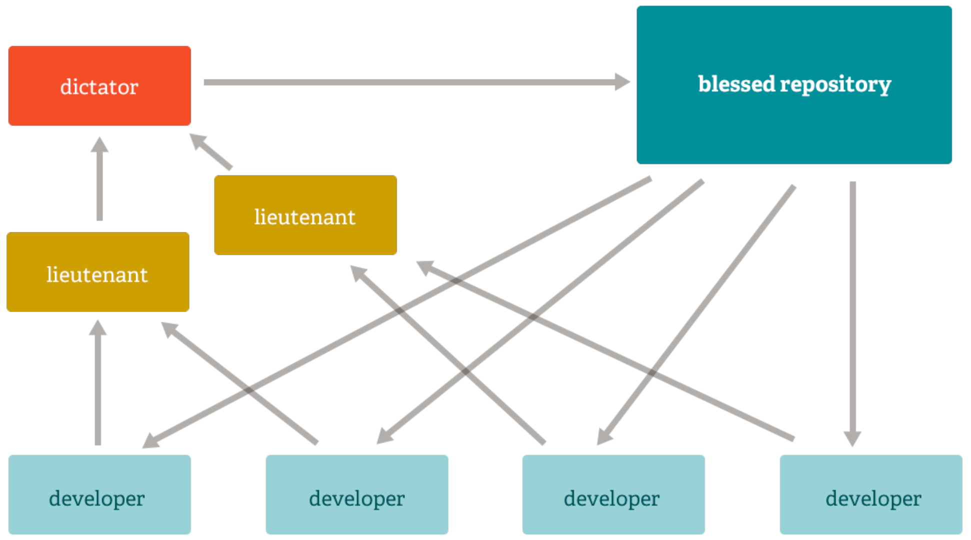


2. Definition of Terms

- **Repository** – directory structure under which all files are stored for a project
  - **Local Repository –** the repository hosted locally on your computer system
    - All project contributors make their changes (**commits**) in their own local repositories
  - **Remote Repository –** the repository hosted remotely on GitHub / GitLab
    - All project contributors **push** their **local changes** (**commits**) to the **remote repository**
    - All project contributors **pull** changes (**commits**) from the **remote repository** into their **local repositories**

- **Branches** – the different workflows or paths in a **repository**
  - Each **repository** has *at least* one **branch** (the default branch is called **master**)
  - Branches get sync'd between **remote** and **local repositories**
  - Branches can be **created**, **deleted**, and **merged**
  - Branches can be used as a *playground* for your changes so that they do not interfere with the **master** branch

- **Clone** – the process of creating a **local copy** of a **remote repository**

2. Definition of Terms

- **Commit** – a change (or snapshot in time)
  - Each **branch** consists of **commits**
  - Each **commit** has a unique SHA or hash (40 character checksum) by which it is identified
  - A commit considers only **diffs** or **deltas** from the previous commit

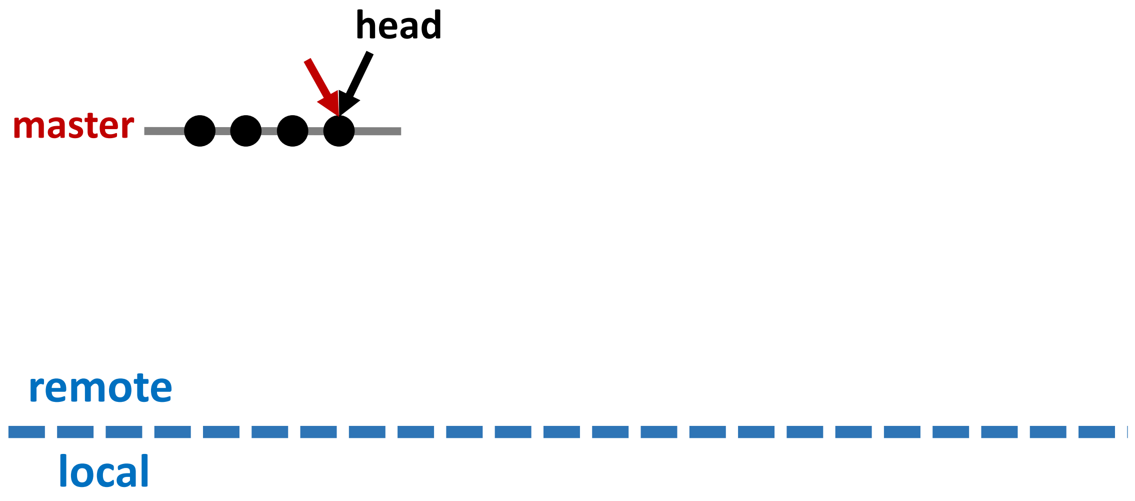
- **Checkout** – the process of selecting a specific **branch** or **commit** (snapshot)

- **Pull** – the process of **fetching** commits from the **remote repository** and **merging** the differences into the **local repository**
  - **Fetch –** get/copy commits from the remote repository, into the local repository
  - **Merge –** account for all differences between the local repository and remote repository

- **Push** – send changes from the **local repository** to the **remote repository**
  - This is frequently preceded by a **pull**
  - Permissions in the remote repository may prevent you from performing a **push** and may instead require a formal **pull-request** (e.g. merge-request) through GitHub / GitLab

2. Definition of Terms (Visually)

- Consider a **remote repository** with one **branch**
  - Dots represent **commits**
  - Small arrows represent **pointers** to **commits**



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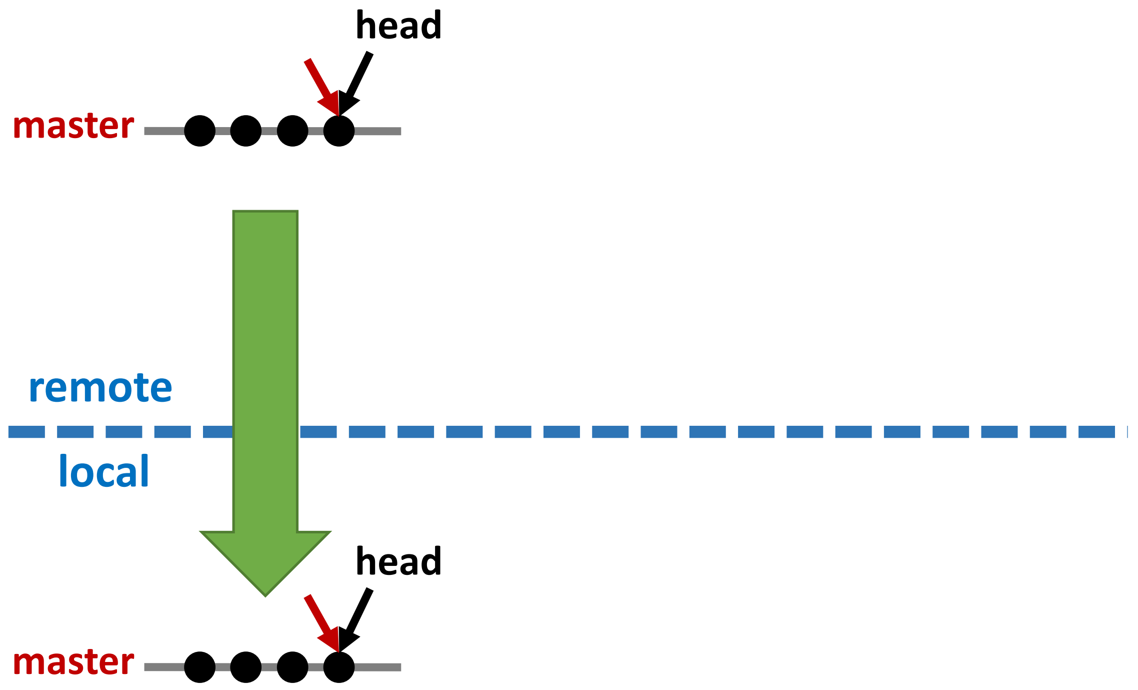
- **Clone** the remote repository locally



2. Definition of Terms (Visually)

- Consider a **remote repository** with one **branch**
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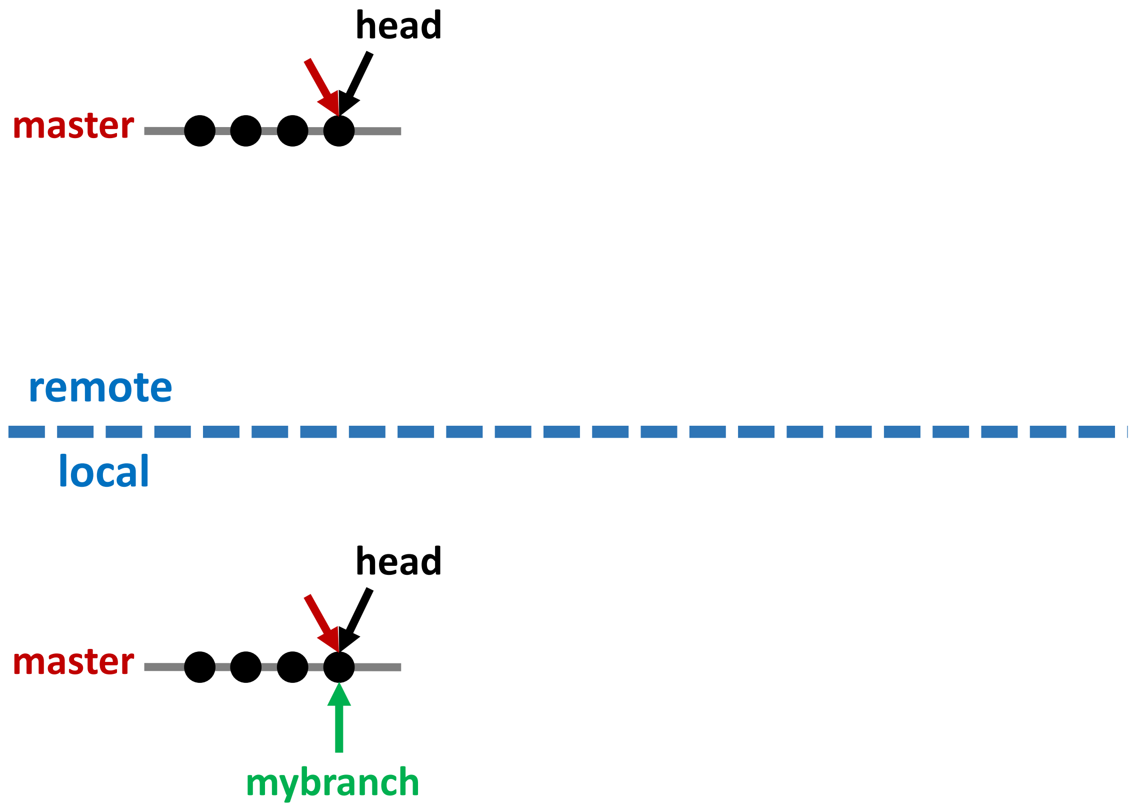
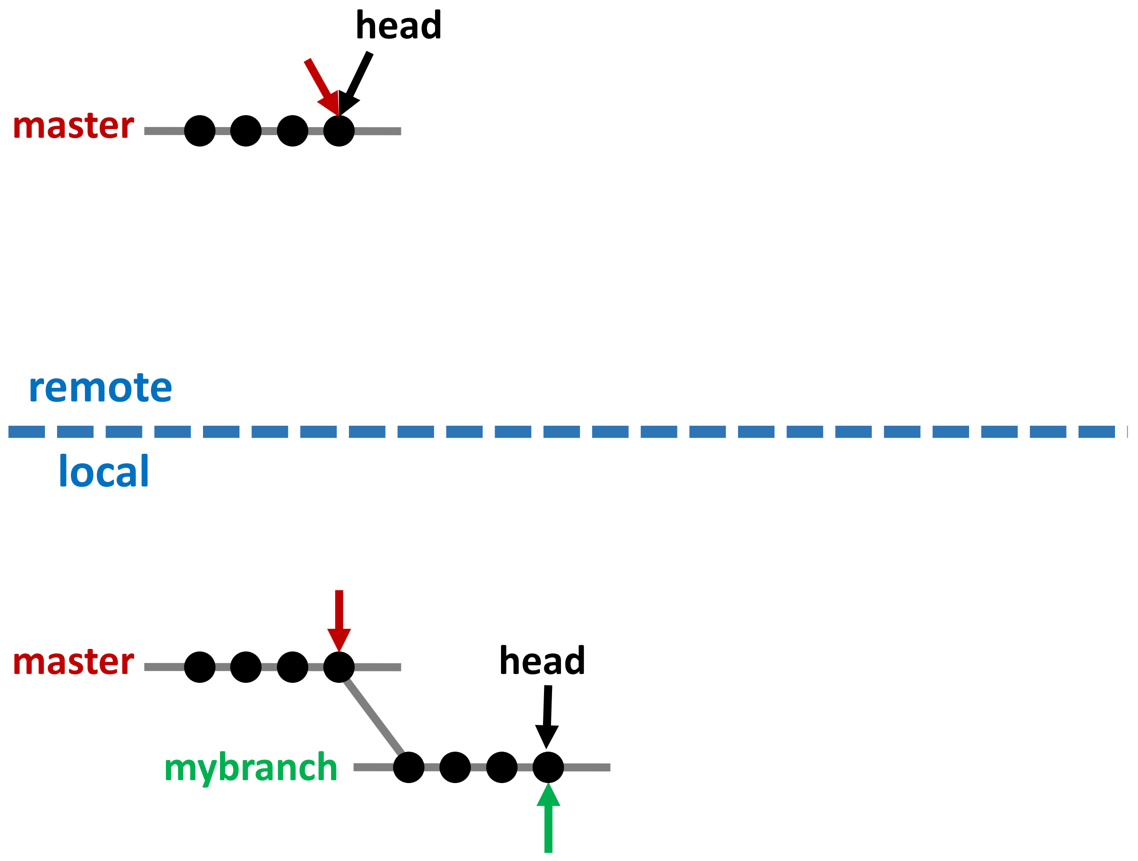
- Create a new **branch** in the **local** **repository**



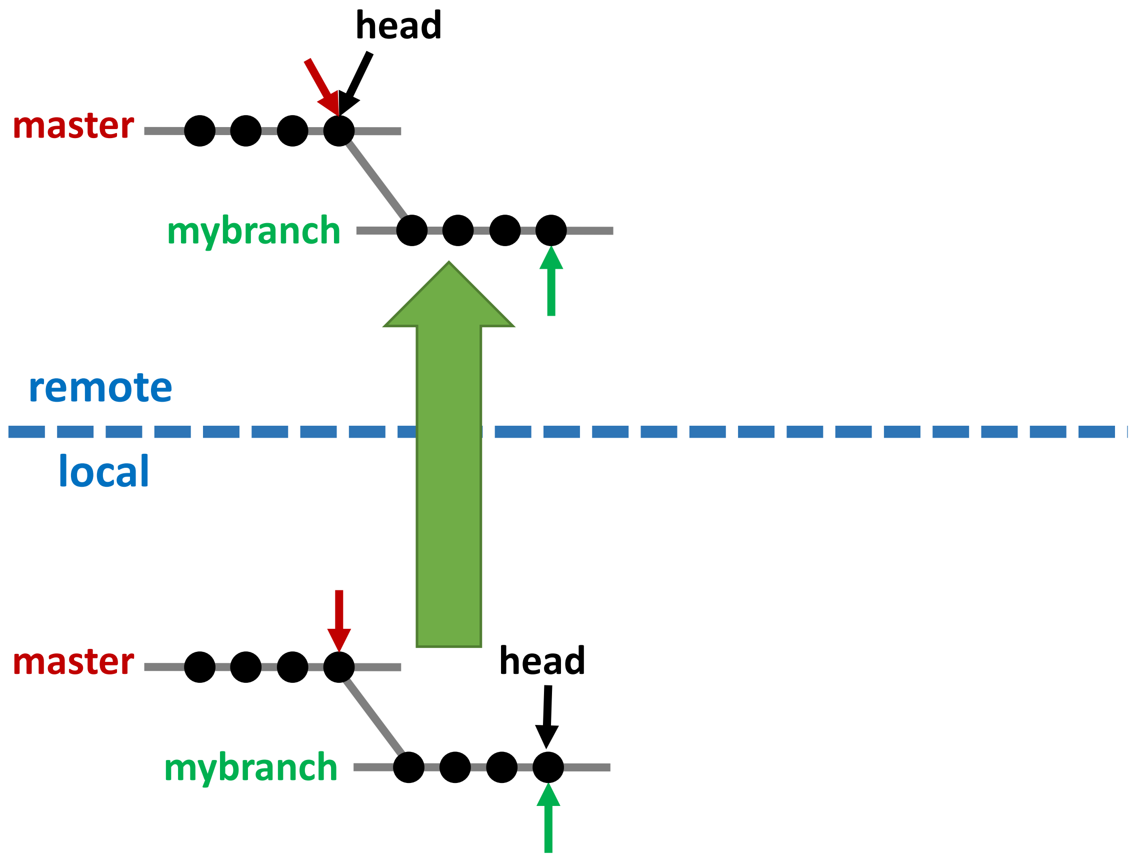
2. Definition of Terms (Visually)

- **Clone** the remote repository locally
- Create a new **branch** in the **local repository**
- Make **commits** to the **new branch**
  - **Head** is a pointer the current commit in your workspace



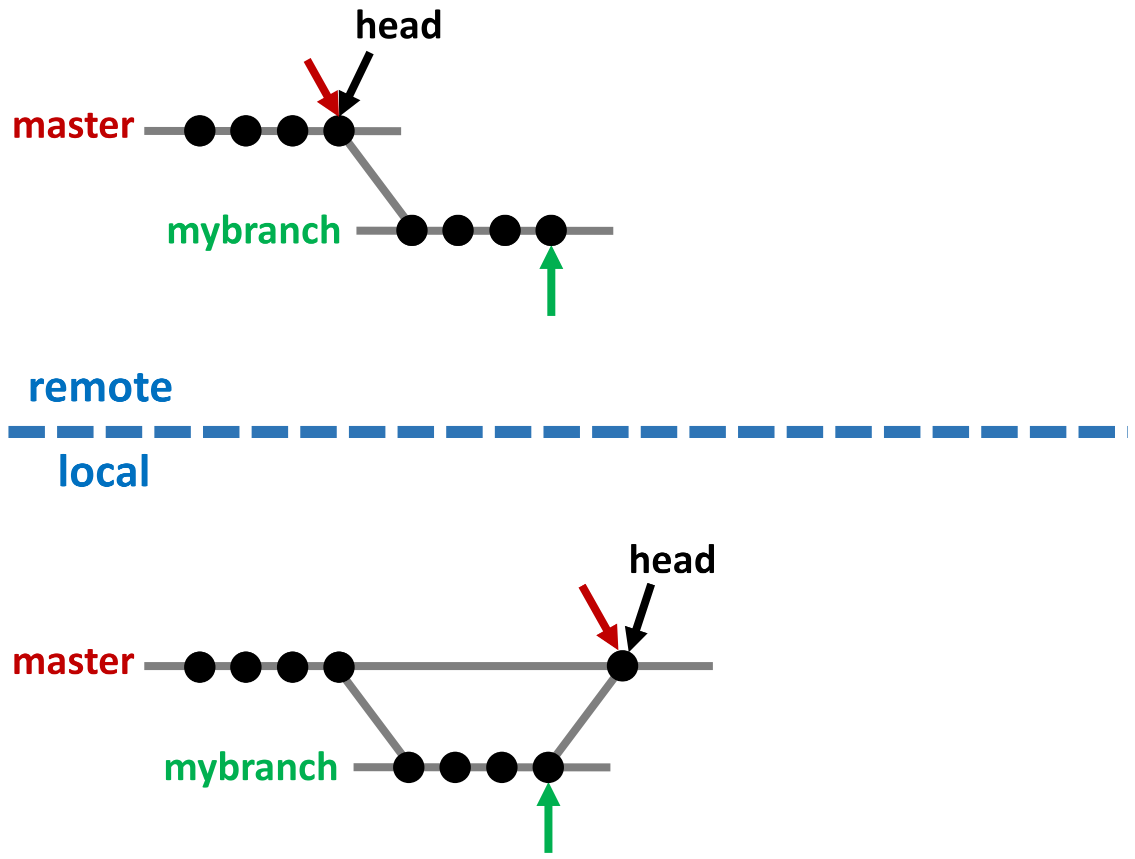
2. Definition of Terms (Visually)

- Create a new **branch** in the **local repository**
- Make **commits** to the **new branch**
  - **Head** is a pointer the current commit in your workspace
- **Push** all commits associated with the **new branch** to the **remote repository**



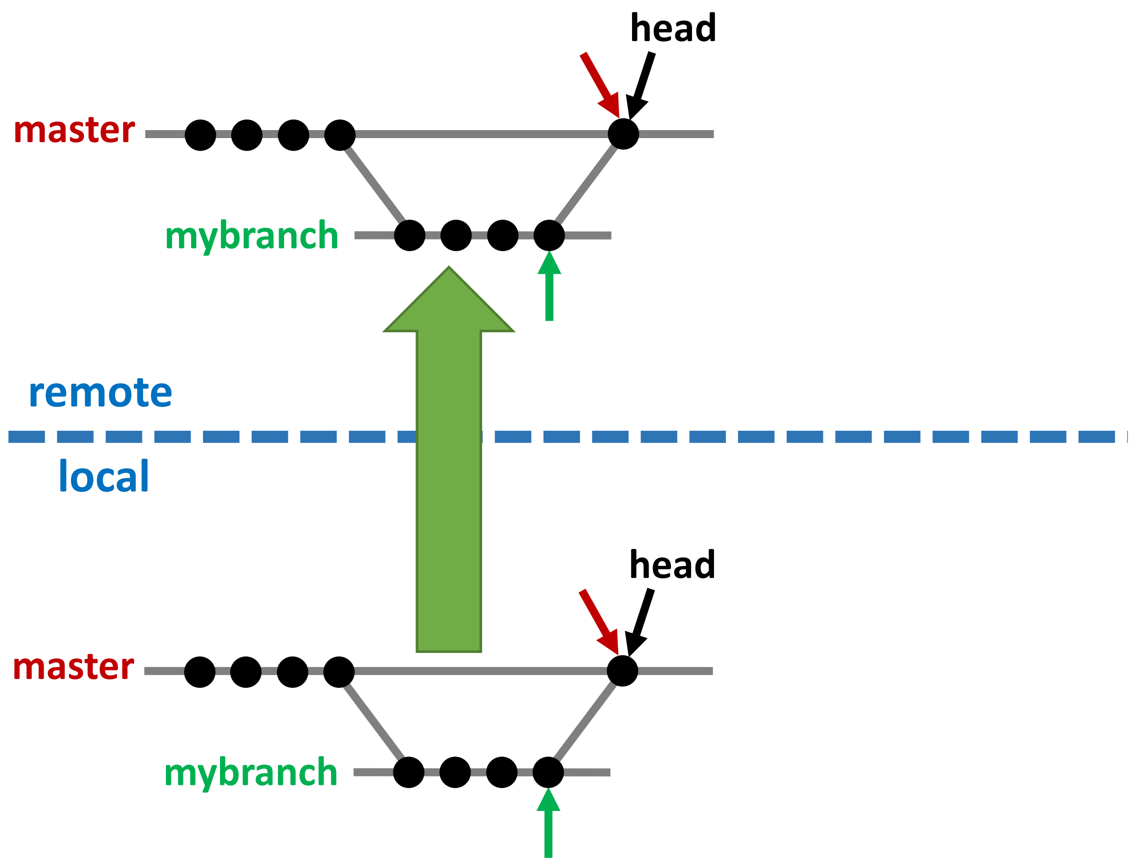
2. Definition of Terms (Visually)

- Make **commits** to the **new branch**
  - **Head** is a pointer the current commit in your workspace
- **Push** all commits associated with the **new branch** to the **remote repository**
- **Merge** the **new** branch into the **master** branch



2. Definition of Terms (Visually)

- **Push** all commits associated with the **new branch** to the **remote repository**
- **Merge** the **new** branch into the **master** branch
- **Push** all changes to the remote repository

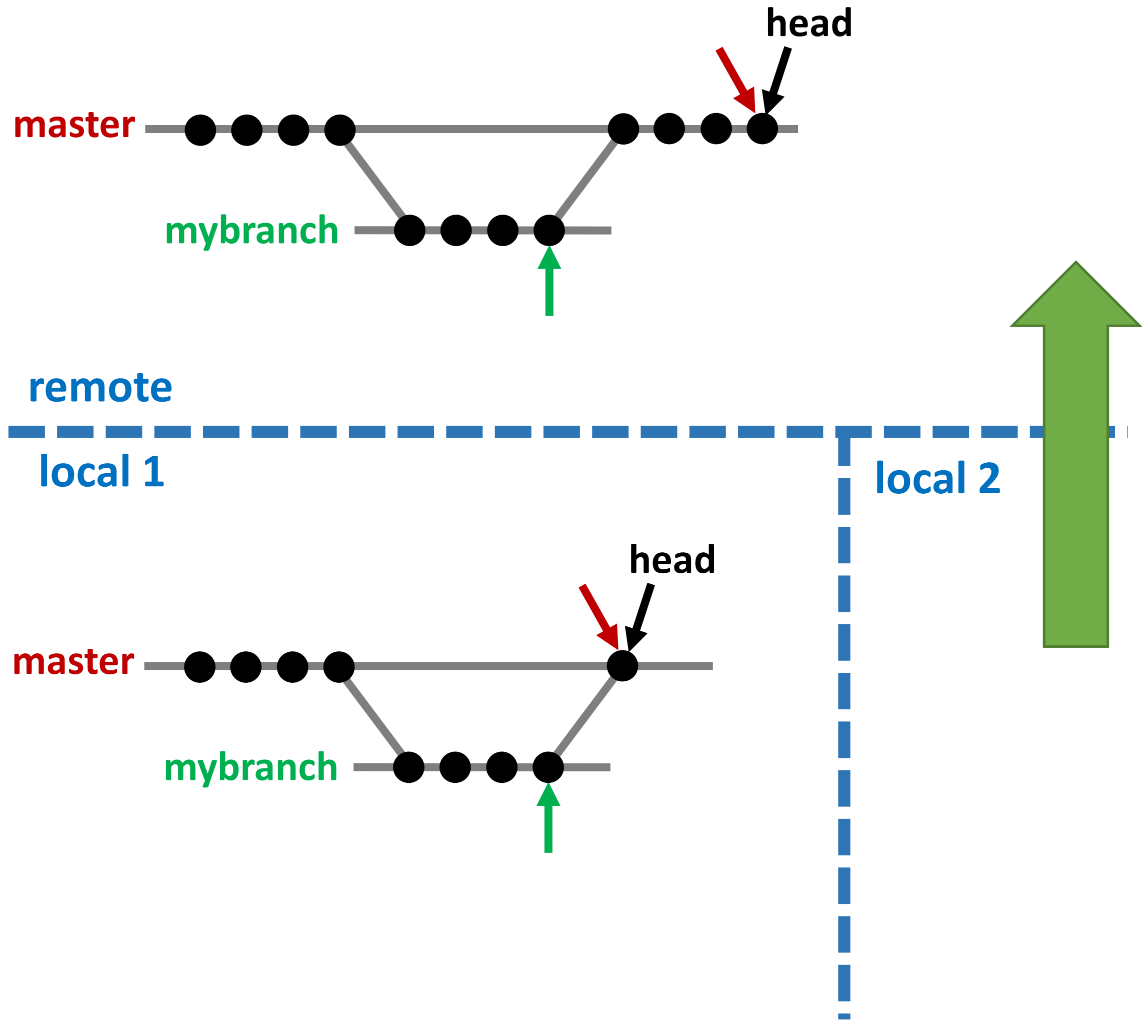


2. Definition of Terms (Visually)

- **Merge** the **new** branch into the **master** branch

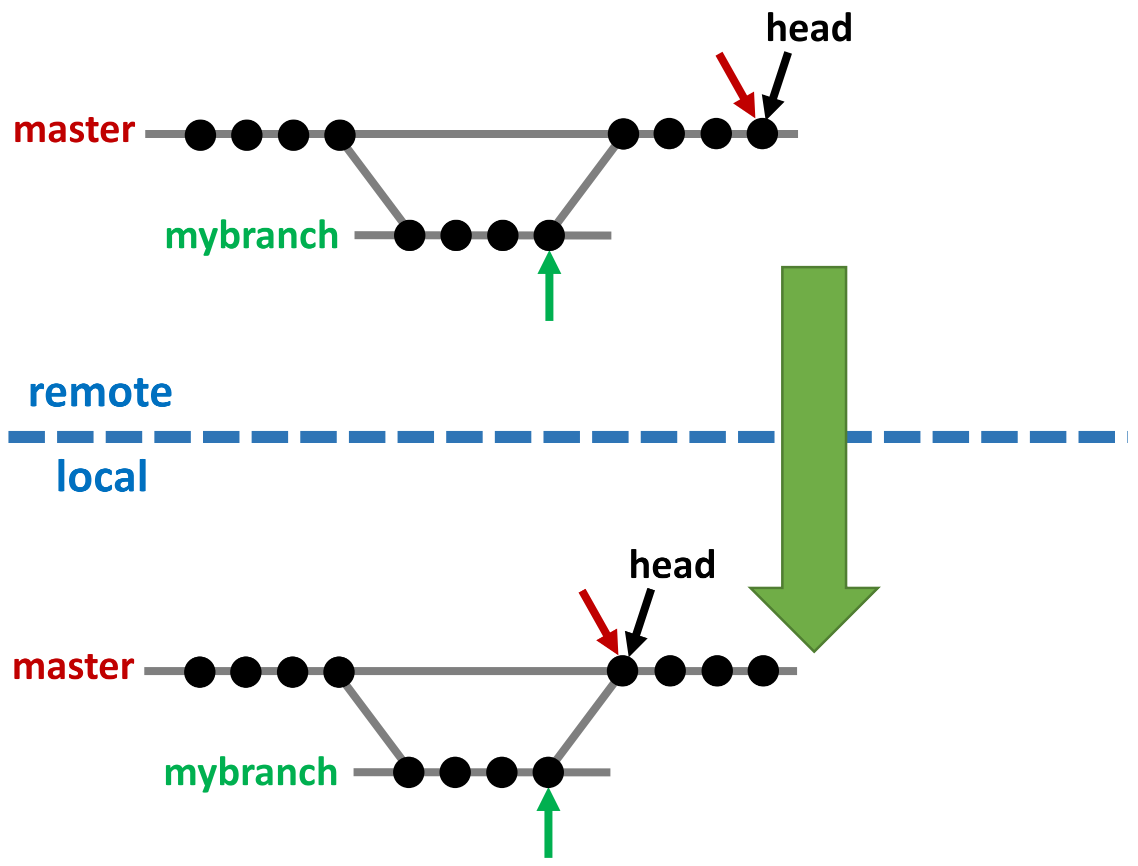
- **Push** all changes to the remote repository

- Suppose another developer **pushes** changes to the **remote repository**



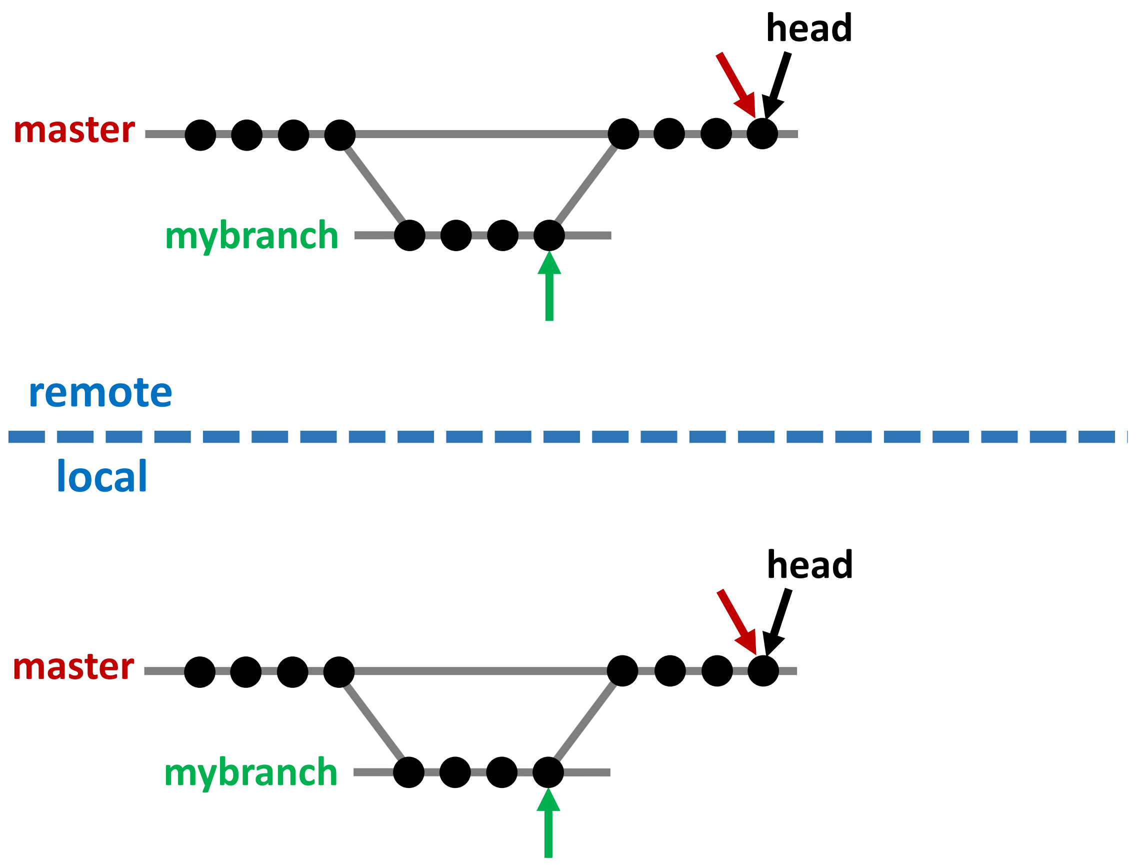
2. Definition of Terms (Visually)

- **Push** all changes to the remote repository
- Suppose another developer **pushes** changes to the **remote repository**
- **Fetch** the new commits from the **remote repository**

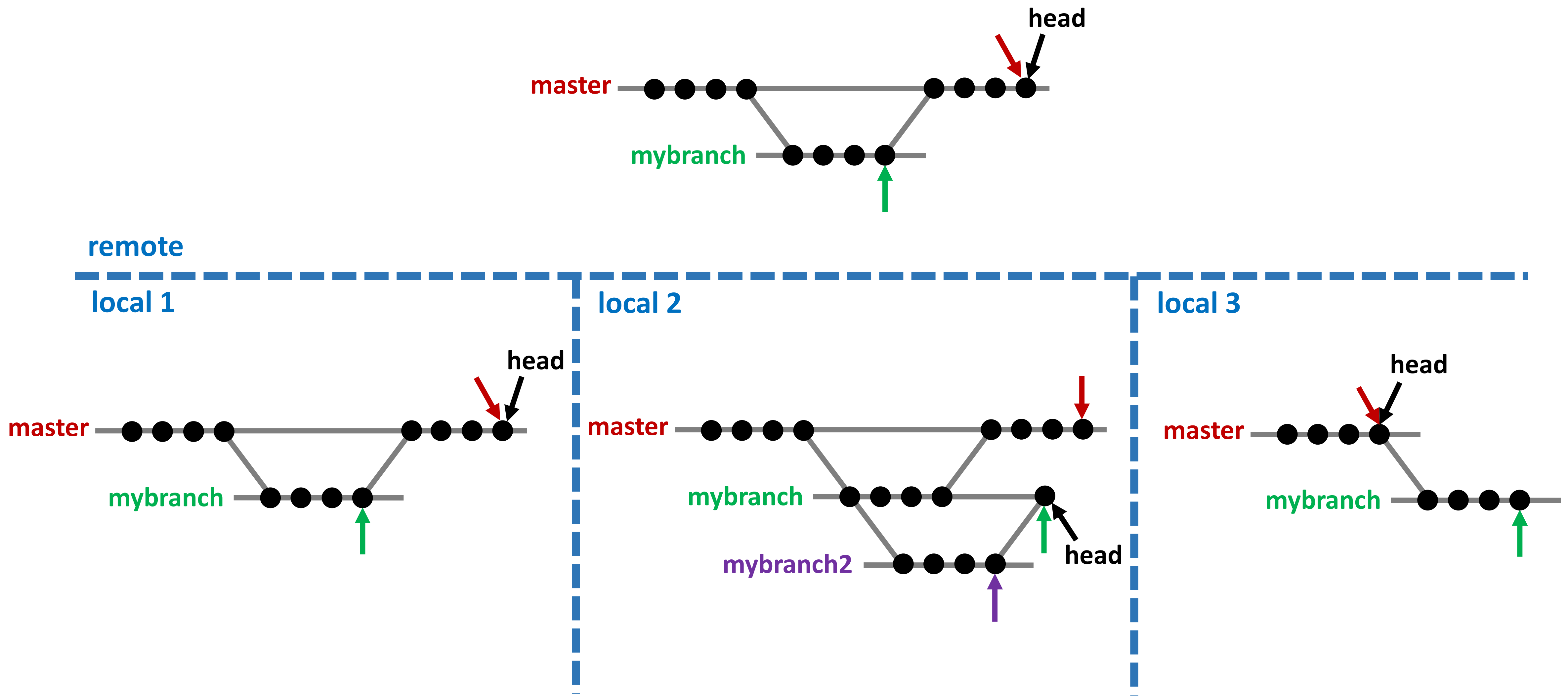


2. Definition of Terms (Visually)

- Suppose another developer **pushes** changes to the **remote repository**
- **Fetch** the new commits from the **remote repository**
- **Merge** the differences in your local repository



2. Snapshot of Git Repositories



3. Navigating with Git

- The process of promoting code/changes is as follows:
  1. Source code changes made locally in **workspace** (Git is unaware)
  2. **Stage** the files that changed (e.g. tell Git which files you want to commit)
  3. **Commit** the files that changed to your **local repository** (Git is aware of changes)
  4. **Push** changes from **local repository** to **remote repository**

- All Git operations may be performed by **command-line** or using conveniently designed **user-interfaces** for your OS

- This tutorial relies exclusively on the **command-line** approach
  - Used by most people in the user community
  - Well documented and easy to get help

3. Common and Useful Commands

```
> git clone <repo-location>:<user>/<repo-name>.git
```

- Create a **clone** of the **remote repository** locally

```
> git remote -v
```

- Check the **remote repository** and its **alias**

```
> git checkout <branch-name | commit-SHA>
```

- Look at a particular branch or commit (sets the HEAD pointer)

```
> git checkout –b <branch-name>
```

- Create a new branch and switch to it (sets the HEAD pointer to the new branch)

3. Common and Useful Commands

```
> git pull <remote-repo> <branch>
```

- **Fetch** commits and **merge** differences from a **branch** in the **remote repository**
- **NOTE:** Only state the **remote repository** and **branch name** if it isn't already set

```
> git push <remote-repo> <branch>
```

- **Push** commits to the **remote repository** and its respective branch
- **NOTE:** Only state the **remote repository** and **branch name** if it isn't already set

```
> git push –u <remote-repo> <branch>
```

- **Push** a newly created branch to the **remote repository**

```
> git log --oneline –n10
```

- View the last 10 commits, with each commit taking up a single line

3. Common and Useful Commands

```
> git status
```
- Check the status of tracked files, staged files, and files ready for commit

```
> git add <file(s)>
```
- **Stages** files for **commit**

```
> git commit –m “<Commit message>”
```
- **Commits** all **staged** files with the specified commit message
- Preceded by the **add** command

```
> git revert <commit-hash>
```
- **Revert** or undo a **commit**
- **NOTE:** This adds a new commit to undo a previous commit

3. Common and Useful Commands

```
> git diff <commit-hash-1> <commit-hash-2>
```

- Visually see the differences between two commits
- If only **one** commit-hash is provided, then run **diff** against the HEAD commit
- If no commit-hash is provided, then run diff against the

```
> git diff --stat <commit-hash-1> <commit-hash-2>
```

- List the files that differ between two commits

3. Common and Useful Commands (Visually)

- Consider a **remote repository** with one **branch**
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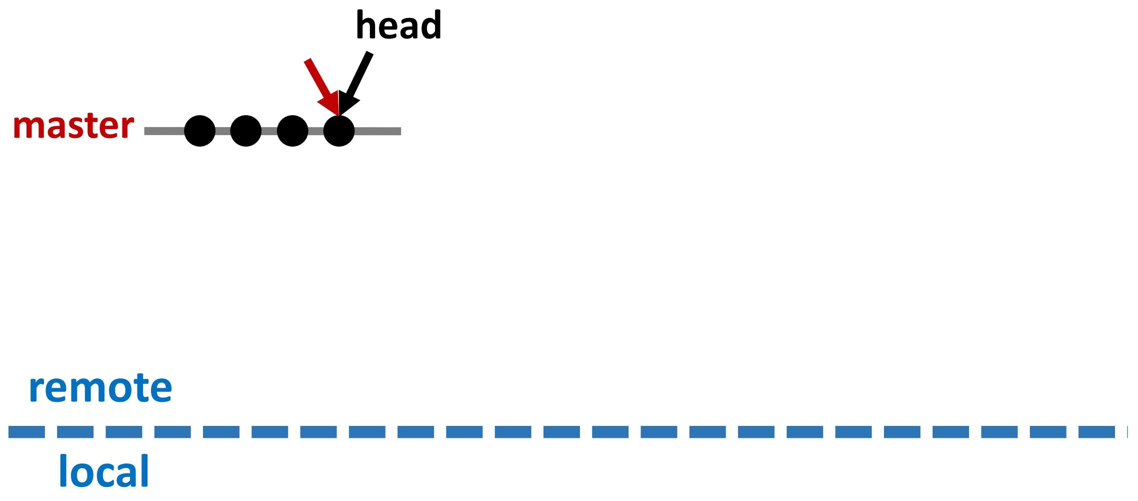

3. Common and Useful Commands (Visually)

- Consider a **remote repository** with one **branch**
  - Dots represent **commits**
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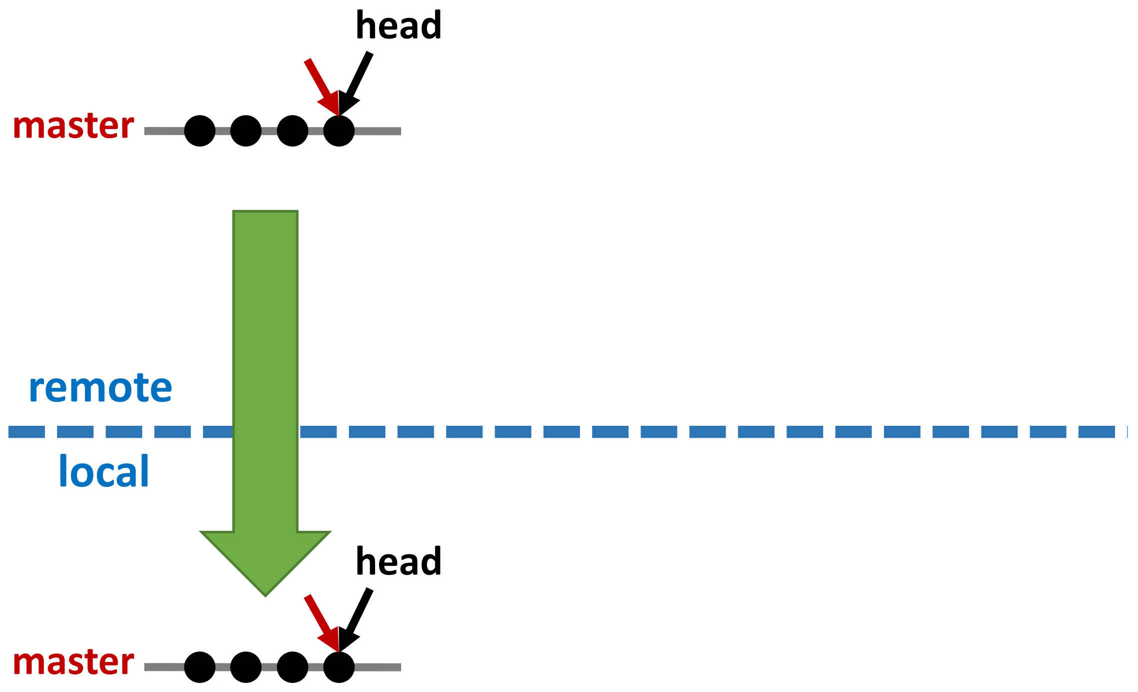
- **Clone** the remote repository locally

```
> git clone
    git@github.com:user1/my_repo
```



3. Common and Useful Commands (Visually)

- **Clone** the remote repository locally

```
> git clone
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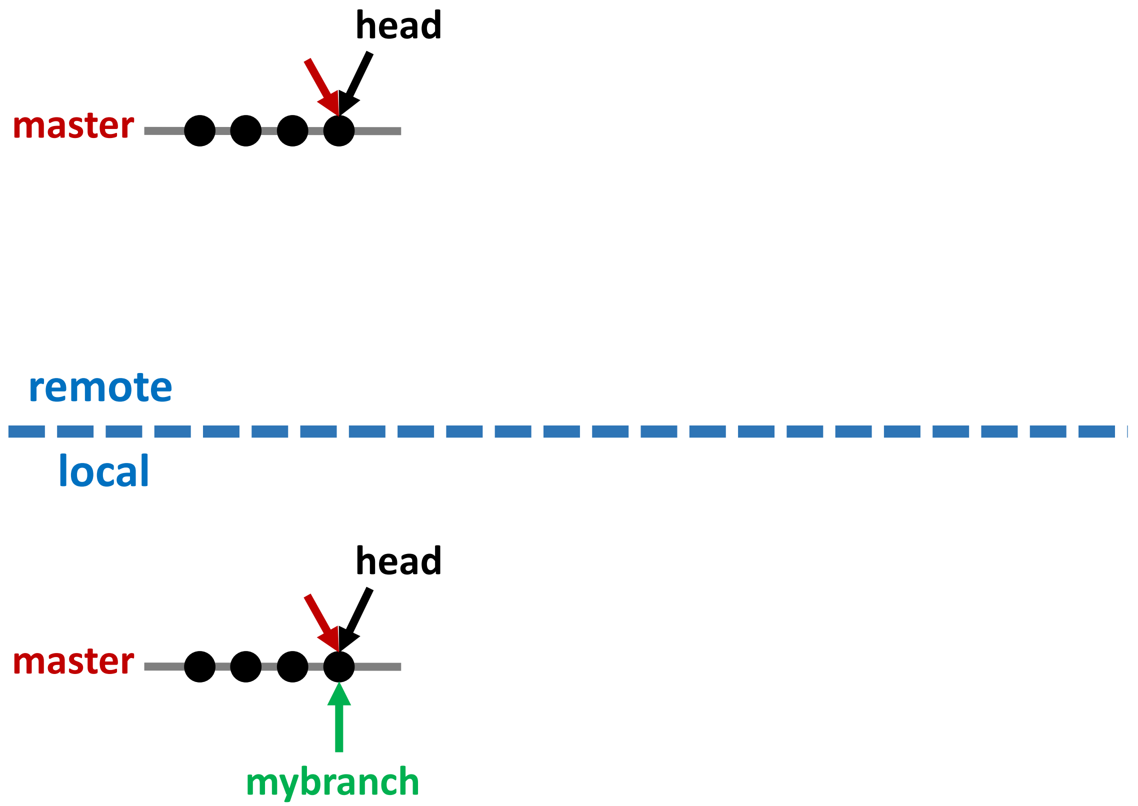
```

- Create a new **branch** in the **local repository**

```
> git checkout -b mybranch
```



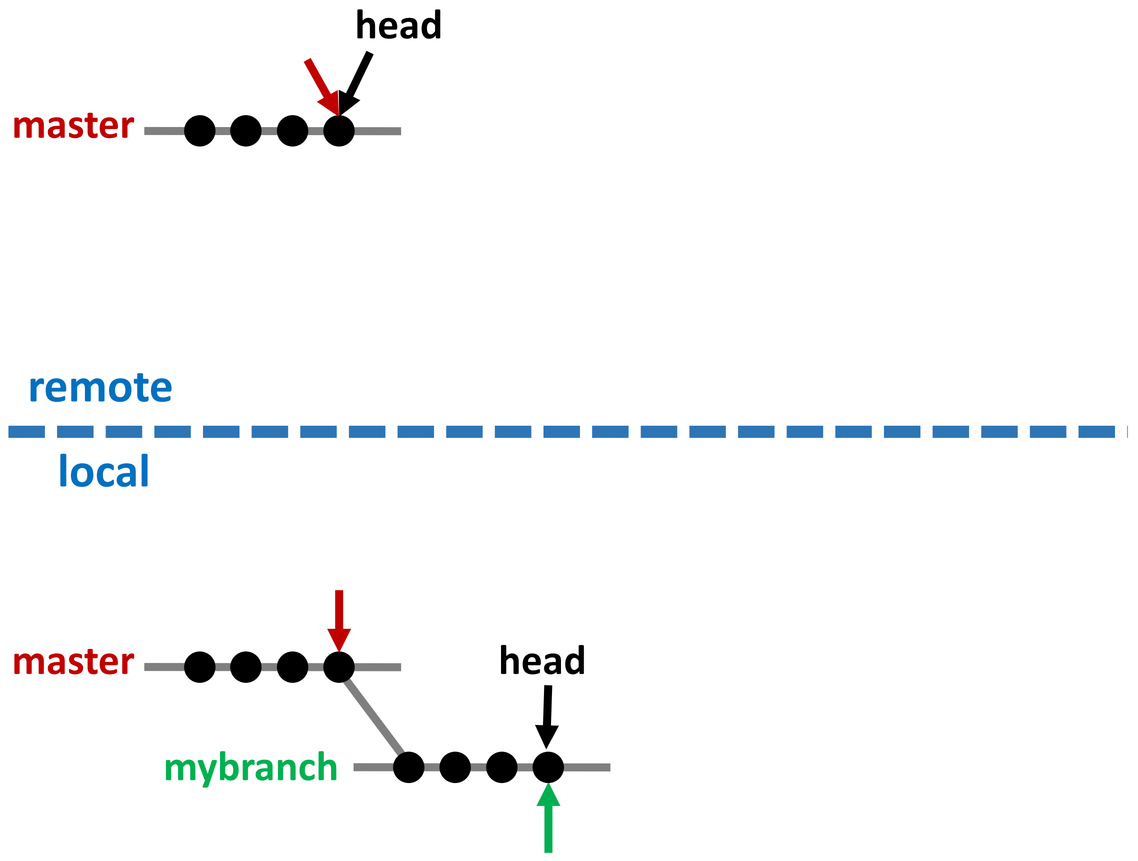
3. Common and Useful Commands (Visually)

- Create a new **branch** in the **local repository**

```
> git checkout -b mybranch
```

- Make **commits** to the **new branch**

```
> # Make changes to files...
> git add <file(s) that changed>
> git commit -m “Initial commit”
```



3. Common and Useful Commands (Visually)

- Make **commits** to the **new branch**

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> # Make changes to files...
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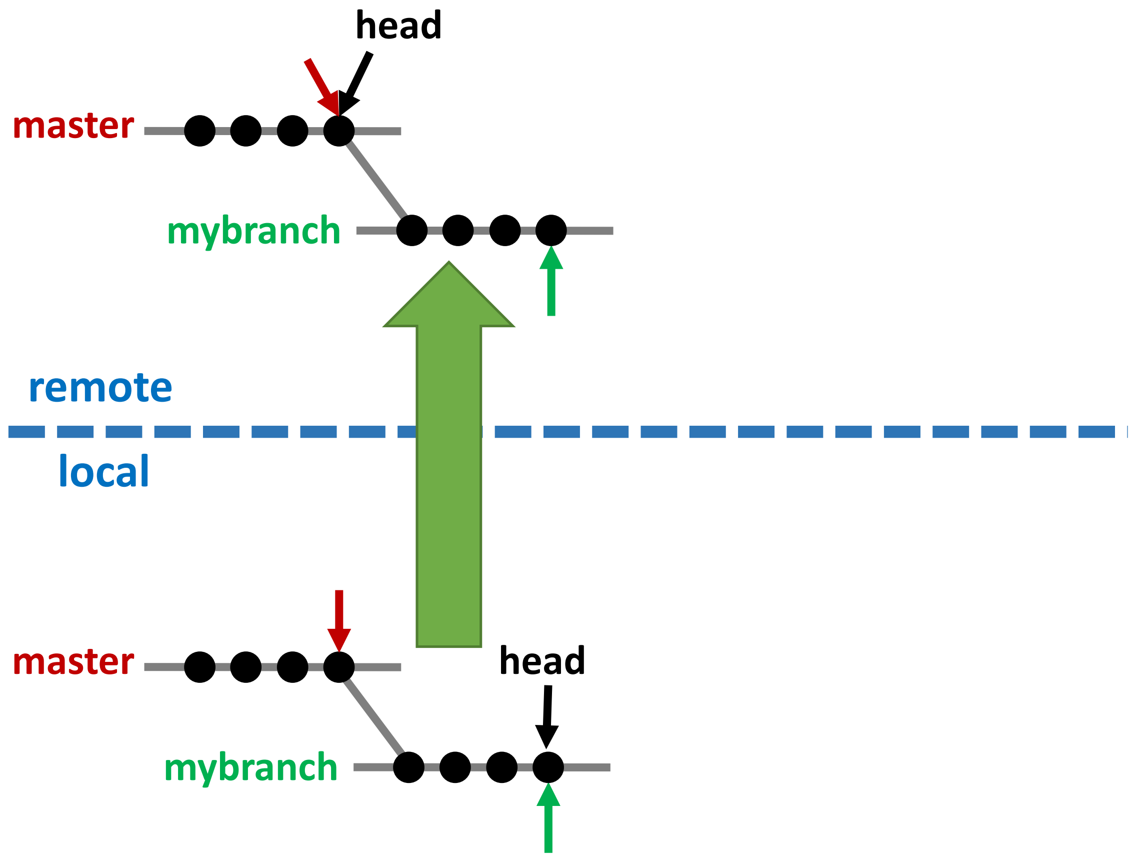
```

- **Push** all commits associated with the **new branch** to the **remote repository**

```
> git push –u origin mybranch
```



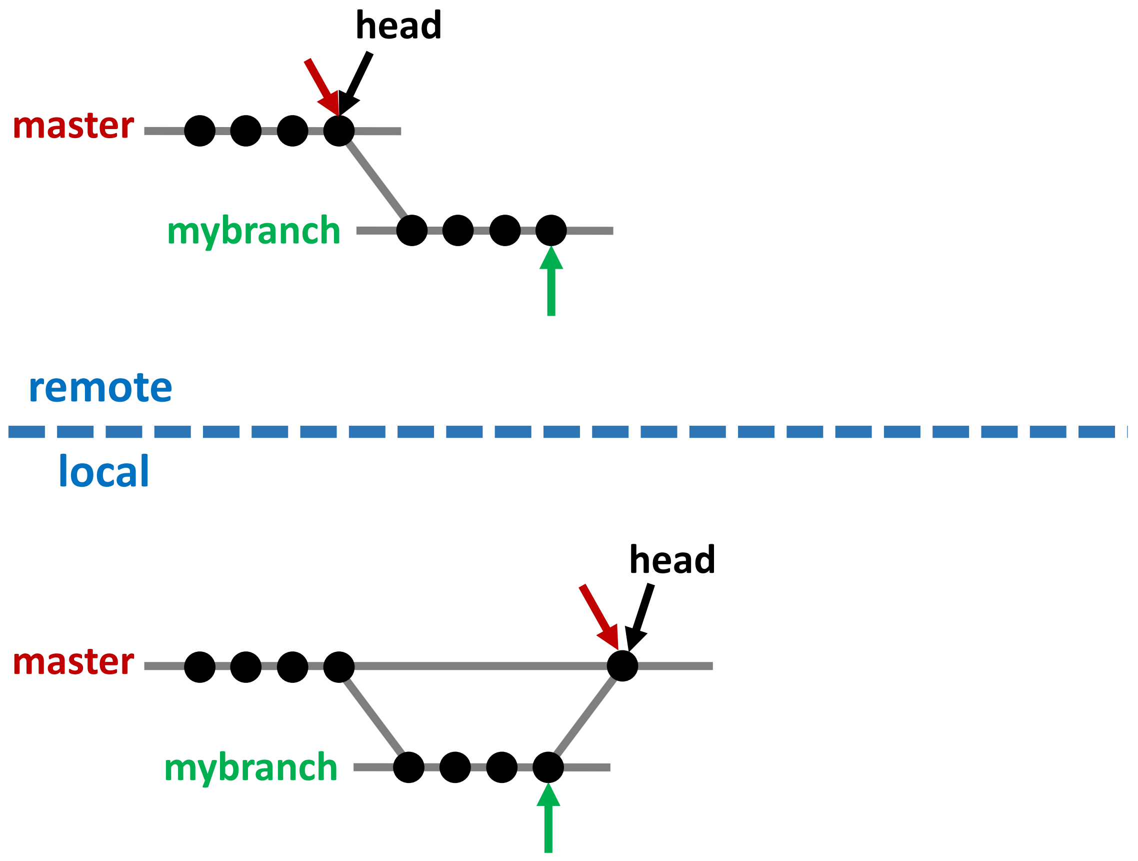
3. Common and Useful Commands (Visually)

- **Push** all commits associated with the **new branch** to the **remote repository**

```
> git push -u origin mybranch
```

- **Merge** the **new** branch into the **master** branch

```
> git checkout master
> git merge mybranch
```



3. Common and Useful Commands (Visually)

- **Merge** the **new** branch into the **master** branch

```
> git checkout master
> git merge mybranch
```

- **Push** all changes to the remote repository

```
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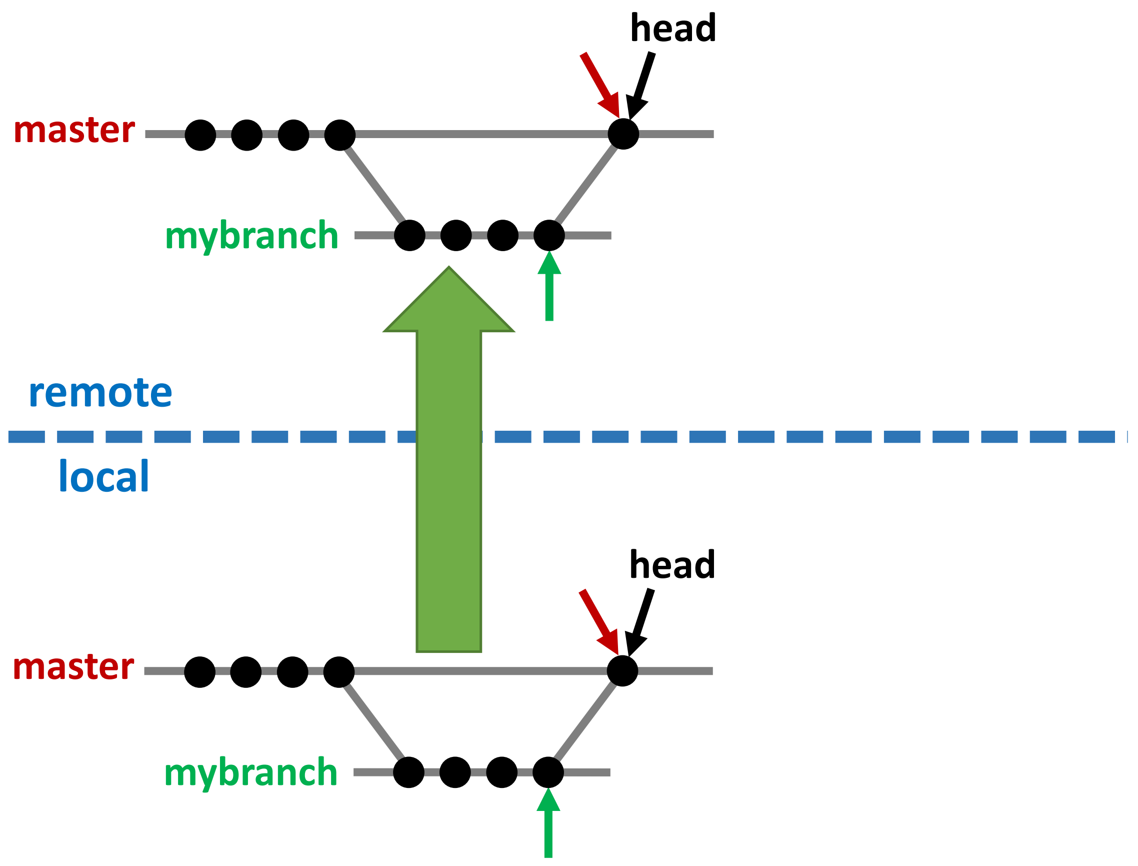
> git push origin mybranch
```

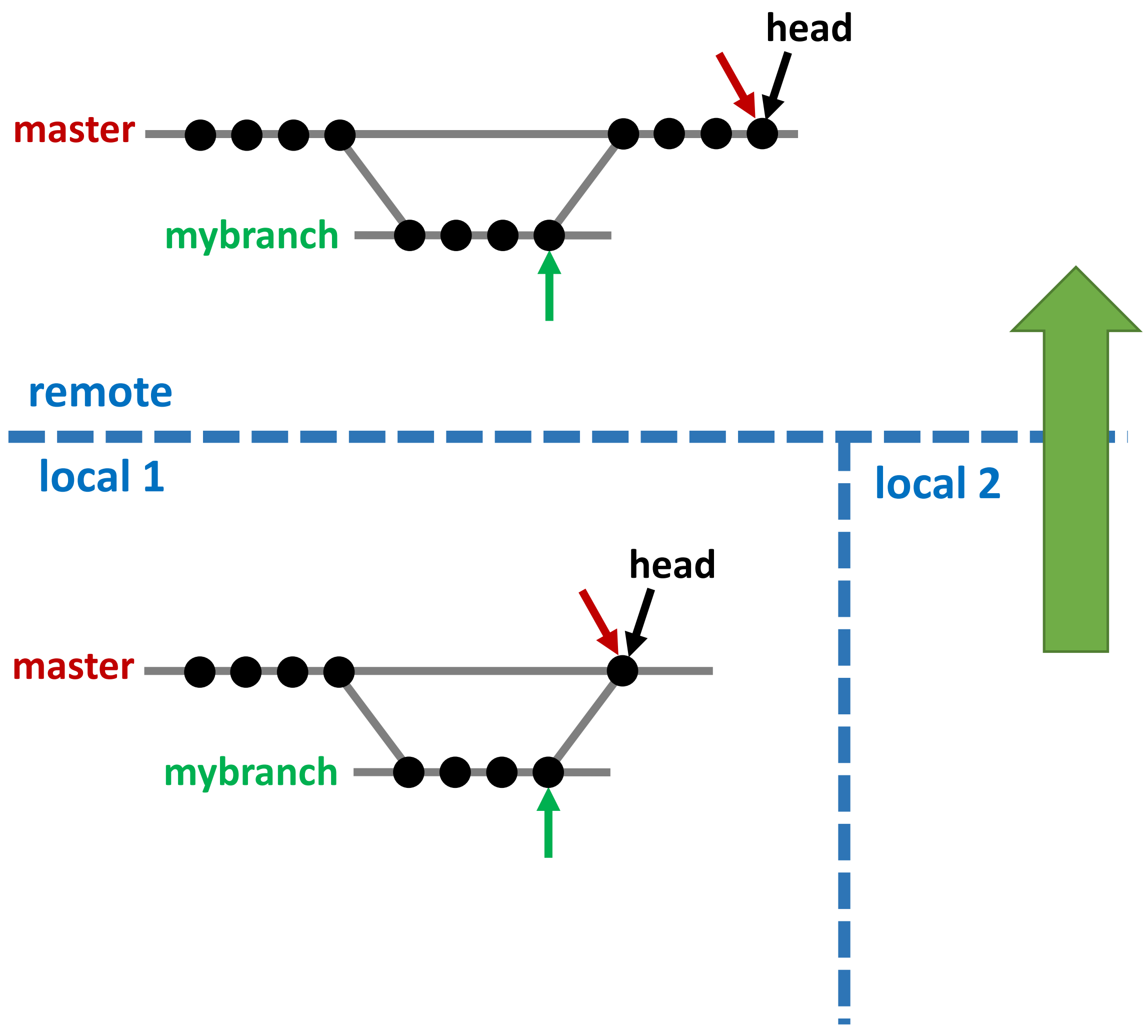


3. Common and Useful Commands (Visually)

- **Push** all changes to the remote repository

```
> git push
> git push origin mybranch
```

- Suppose another developer **pushes** changes to the **remote repository**

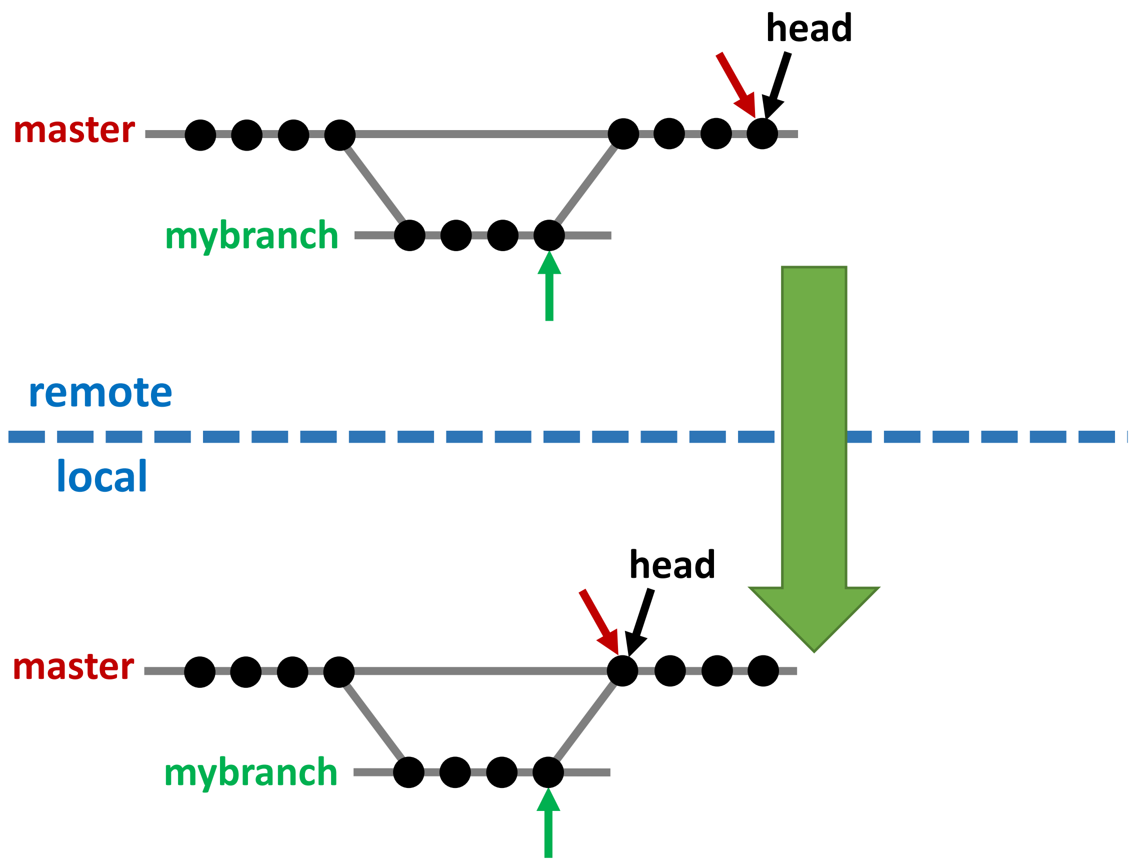


3. Common and Useful Commands (Visually)

- Suppose another developer **pushes** changes to the **remote repository**

- **Fetch** the new commits from the **remote repository**

```
> git checkout mybranch
> git fetch
> git fetch origin mybranch
```



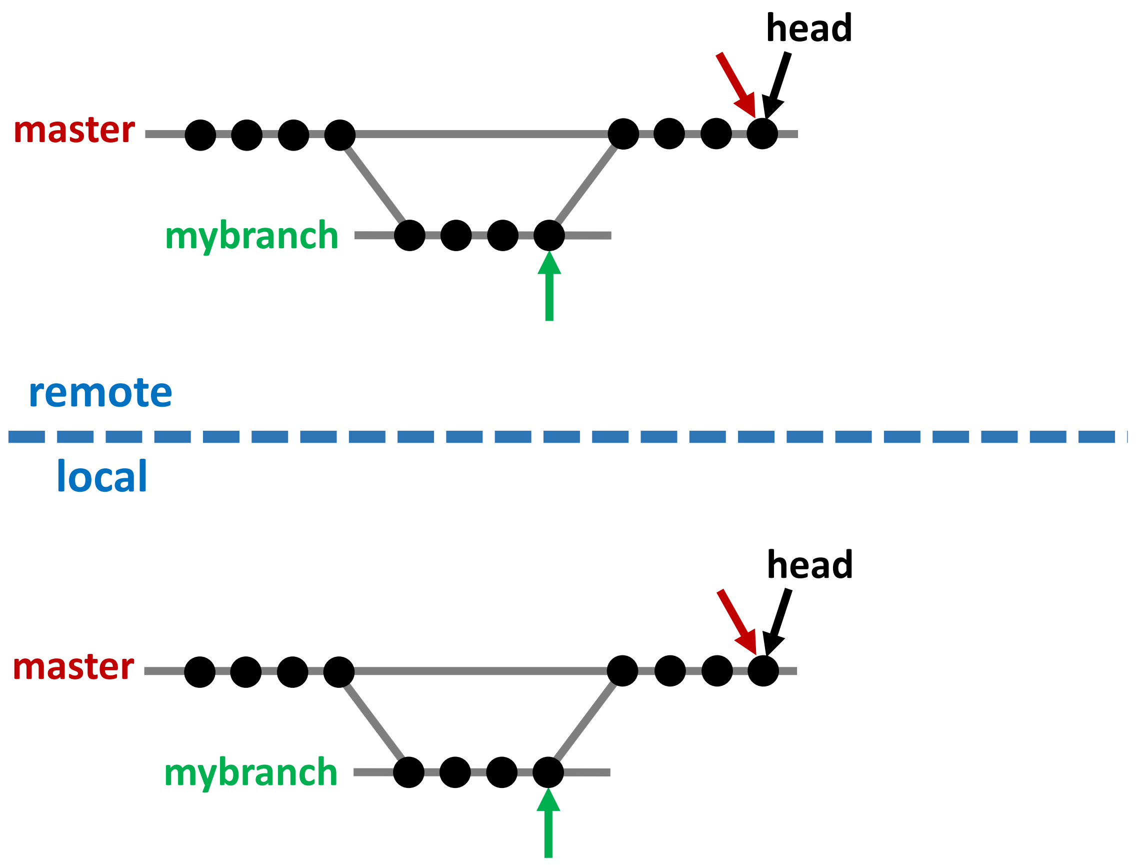
3. Common and Useful Commands (Visually)

- **Fetch** the new commits from the **remote repository**

```
> git checkout mybranch
> git fetch
> git fetch origin mybranch
```

- **Merge** the differences in your local repository

```
> git merge origin mybranch
```



3. Typical Workflow with Common Commands

```
# Clone the repository
> git clone git@github.com:<user>/<repo_name>.git

# Create a new ‘feature’ branch
> git checkout –b my_feature_branch

# Do work locally on your files...

# Get ready to commit your code changes
> git status
> git add <file1> <file2> ... <fileN>
> git commit –m “A meaningful commit message...”

# Make sure you branch is sync’d with the remote repository before pushing commits
> git pull <remote-repo> <branch>
> git push <remote-repo> <branch>
```

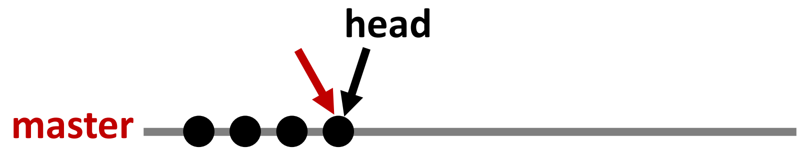
4. Step-by-Step Walkthrough with Git

- Below is the state information for the example to be presented:
  - There exists a **remote repository** with the **master branch** and one file
  - Only one individual is actively making changes to the repository at a time

- The following will be demonstrated:
  - **Branch** creation
  - Changes local to the **workspace**
  - **Staging** and **committing** files
  - Updating the **local** and **remote repositories**

No files in local repository

```
>
```



remote

local

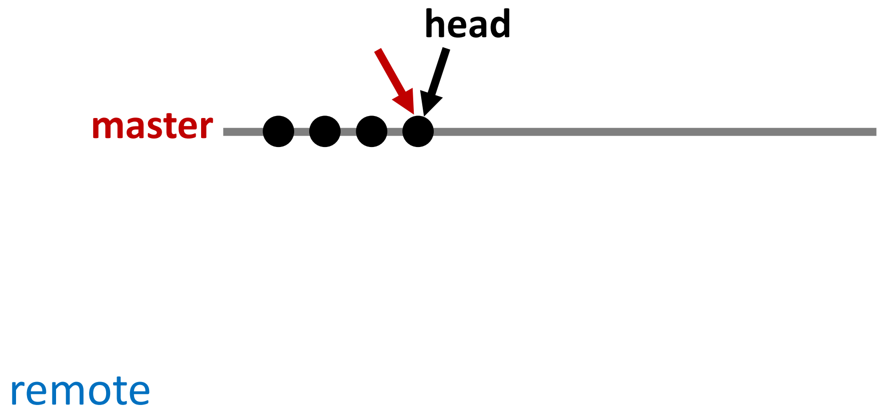
No local repository

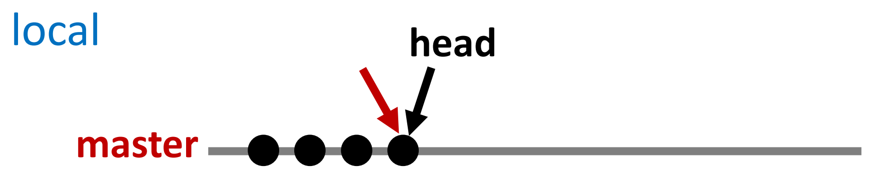
No files in staging area

todo.txt

Things to do:
1. Clone repo
2. Make changes
3. Commit changes
4. Update remote

```
> git clone git@github.com:user/myrepo.git
>
```





Changes for Commit:

Changed Files:

Untracked Files:

todo.txt

Things to do:

1. Clone repo
2. Make changes
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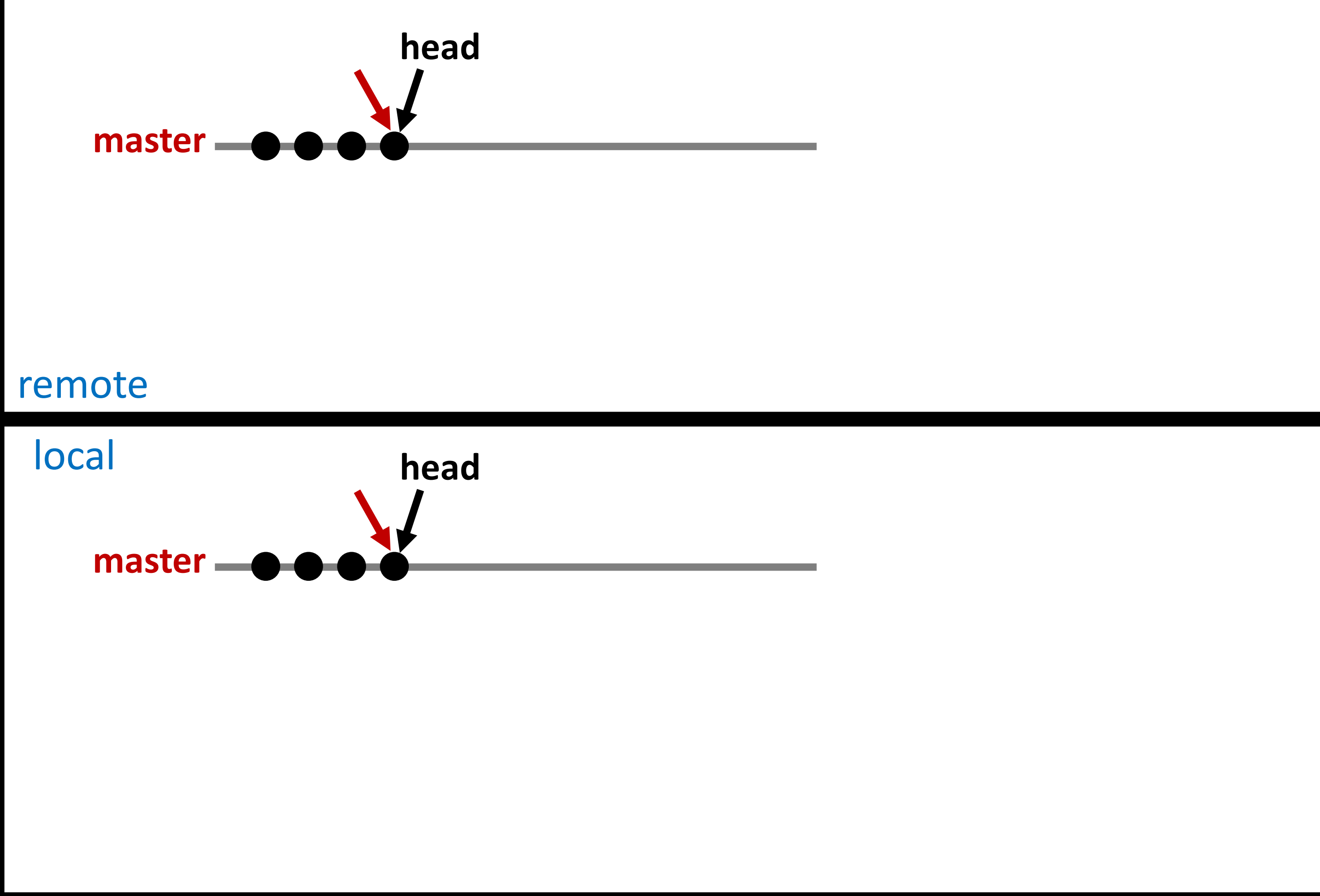
test.txt

```
> git clone git@github.com:user/myrepo.git
>
```



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todo.txt

Things to do:
1. Clone repo
2. Make changes
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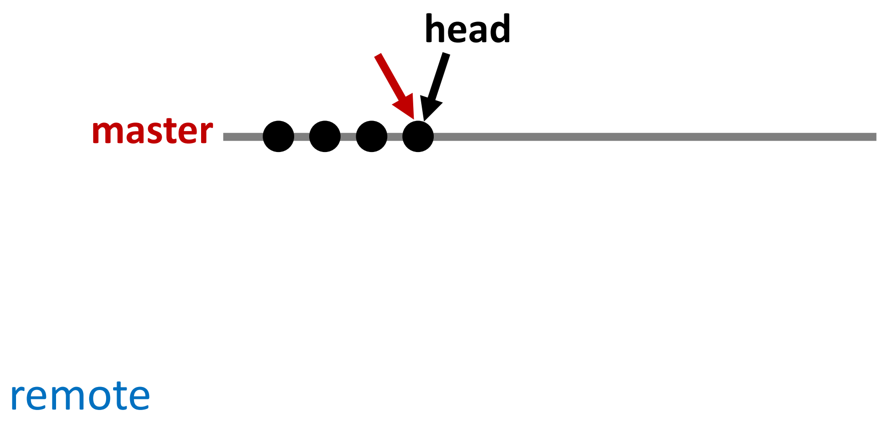
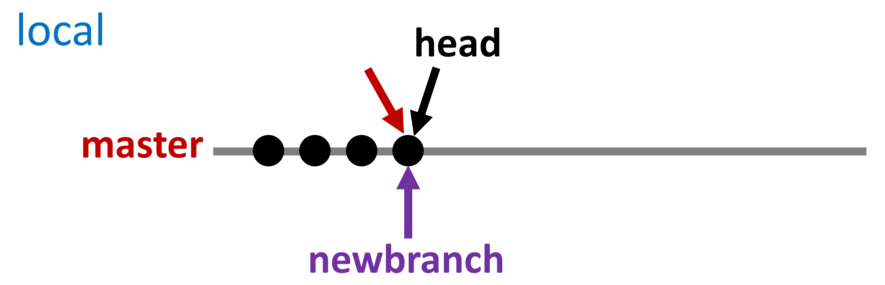
test.txt

```
> git clone git@github.com:user/myrepo.git
> git checkout -b newbranch
```





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test.txt

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Things to do:
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test.txt

Testing…testing…1…2…3

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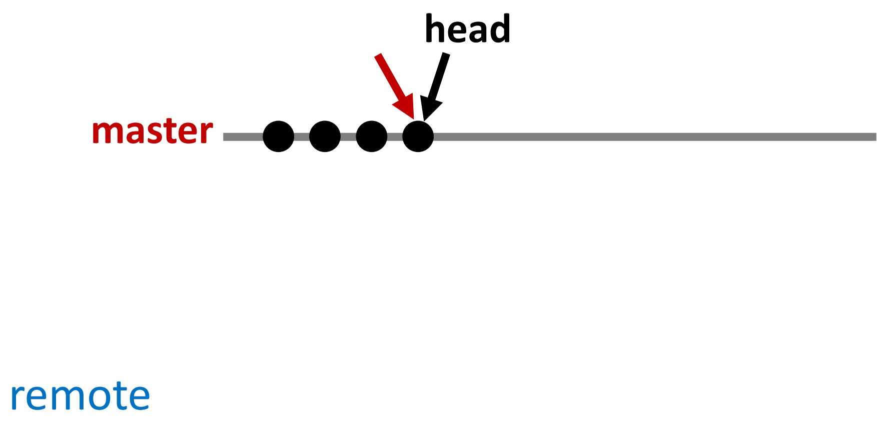
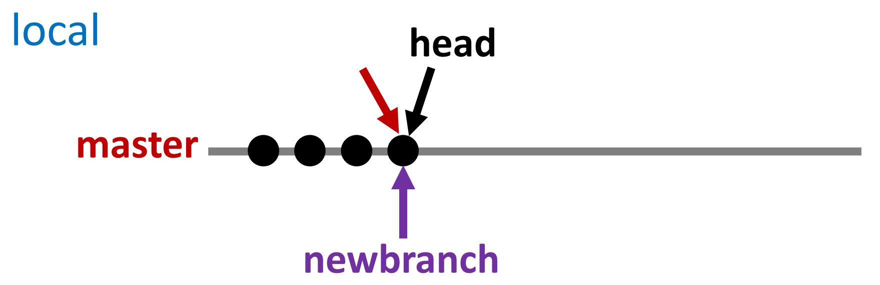
```





Changes for Commit:	Changed Files:	Untracked Files:
		test.txt

todo.txt

Things to do:
1. Clone repo
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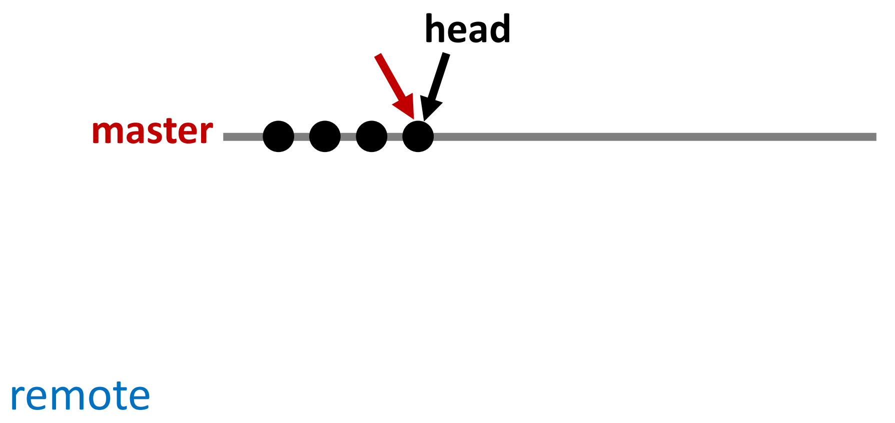
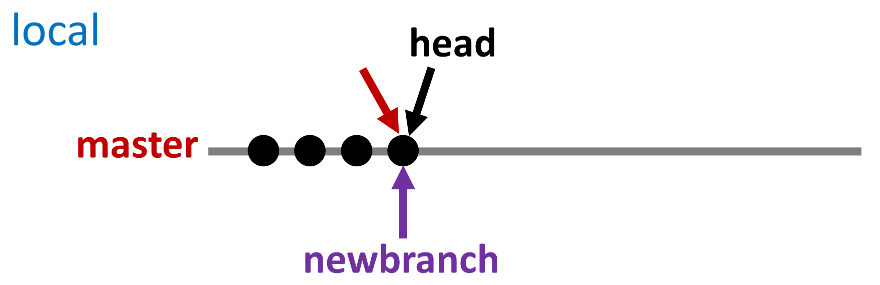
test.txt

Testing...testing...1...2...3

```
> git clone git@github.com:user/myrepo.git
> git checkout -b newbranch
> git add test.txt
```





Changes for Commit:

test.txt

Changed Files:

Untracked Files:

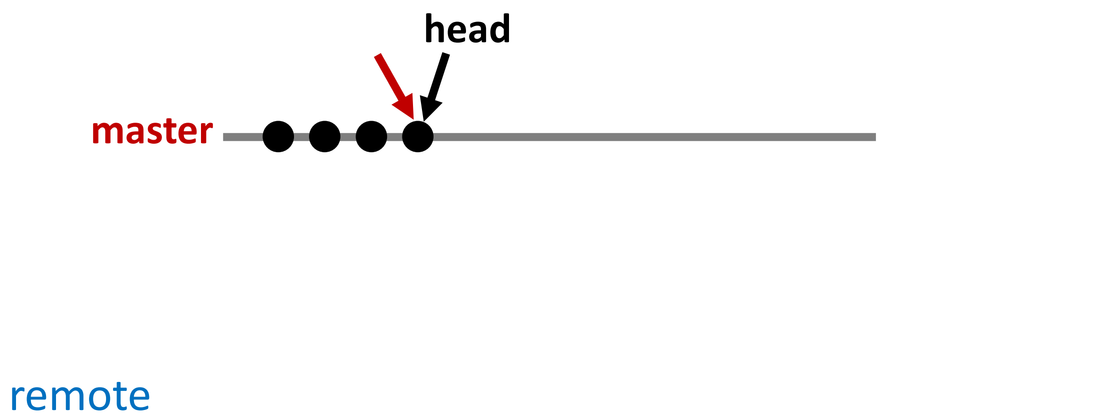
todo.txt

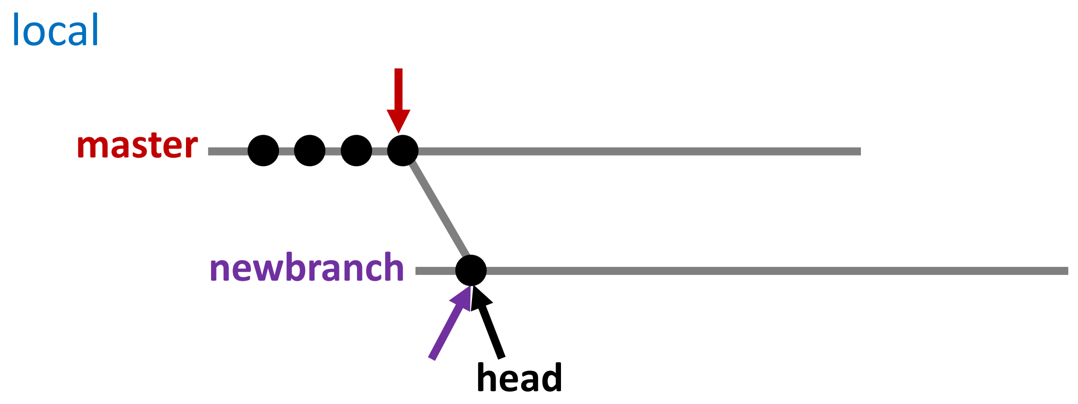
Things to do:
1. Clone repo
2. Make changes
3. Commit changes
4. Update remote
5. Make more changes

test.txt

Testing…testing…1…2…3
Testing…1

```
> git clone git@github.com:user/myrepo.git
> git checkout -b newbranch
> git add test.txt
> git commit -m “Updated test.txt”
>
```





Changes for Commit:	Changed Files:	Untracked Files:
	test.txt	
	todo.txt	

todo.txt

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1. Clone repo
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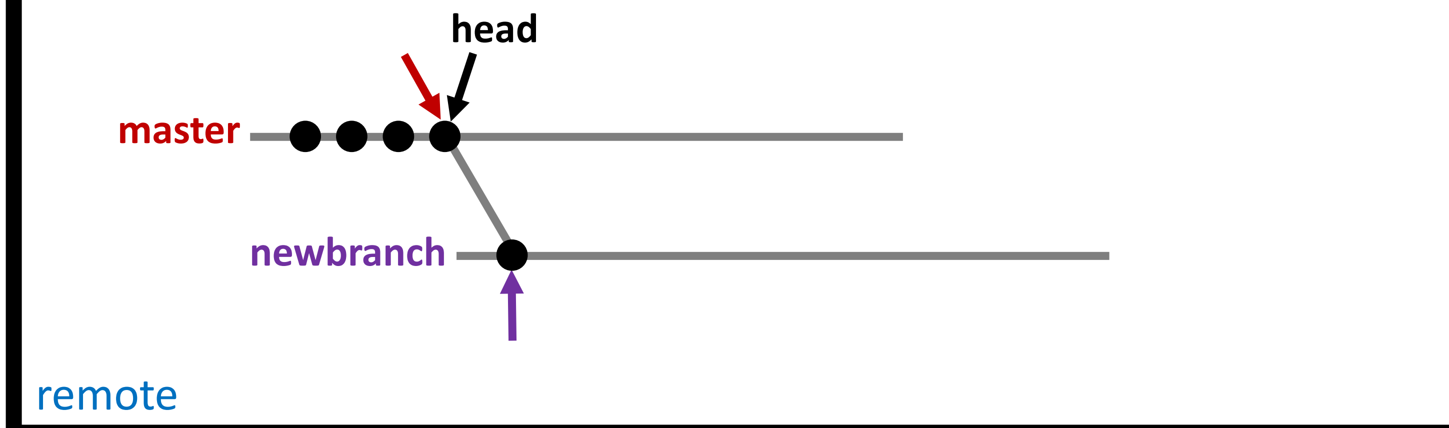
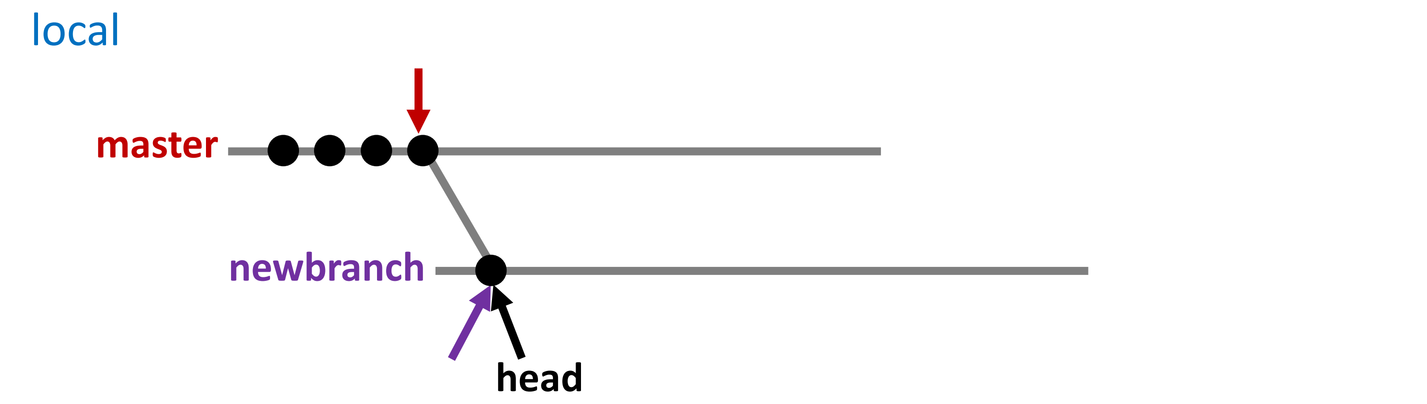
test.txt

Testing…testing…1…2…3
Testing…1

```
> git clone git@github.com:user/myrepo.git
> git checkout -b newbranch
> git add test.txt
> git commit -m “Updated test.txt”
> git push -u origin newbranch
>
```





Changes for Commit:	Changed Files:	Untracked Files:
	test.txt	
	todo.txt	

todo.txt

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test.txt

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Testing…1

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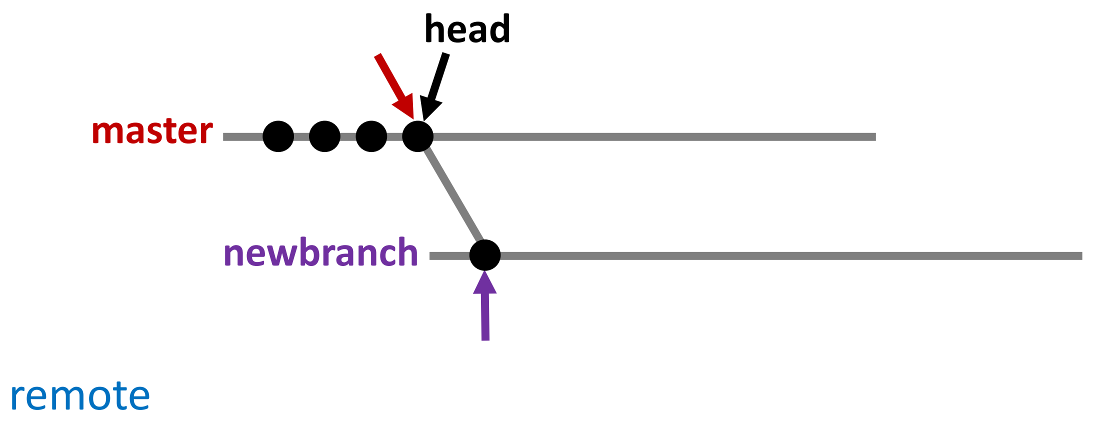

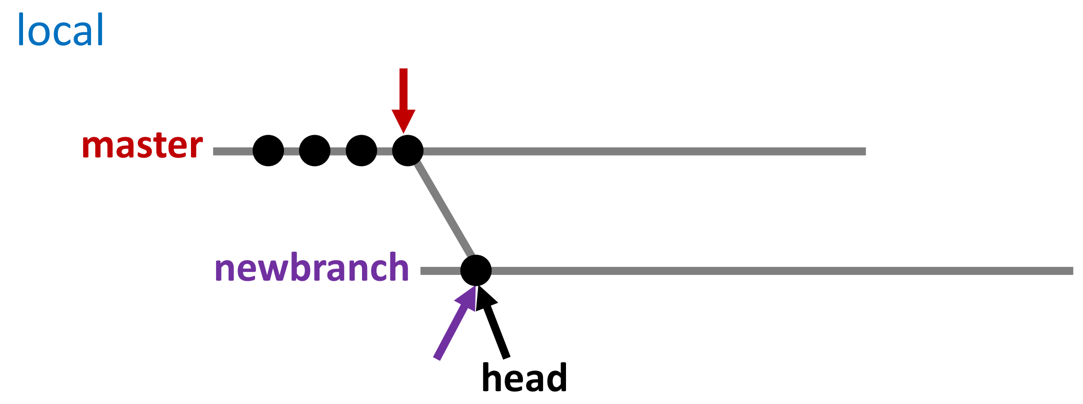

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test.txt

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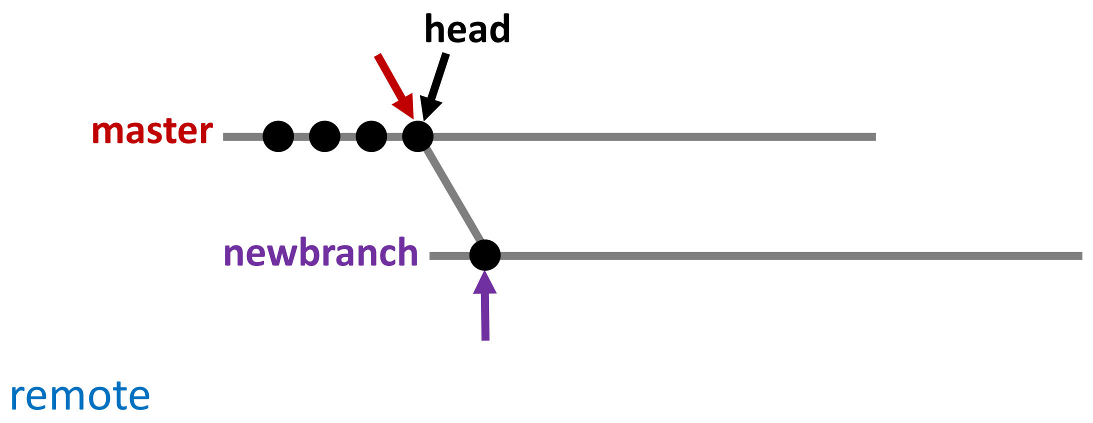

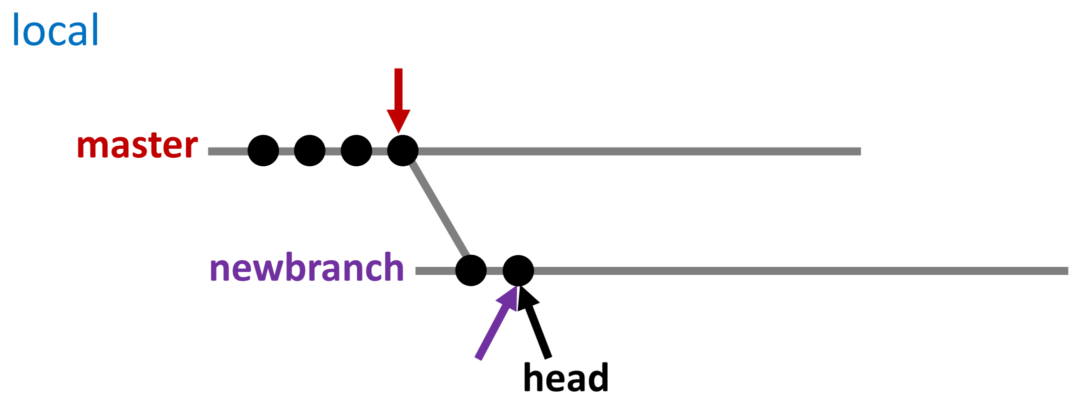

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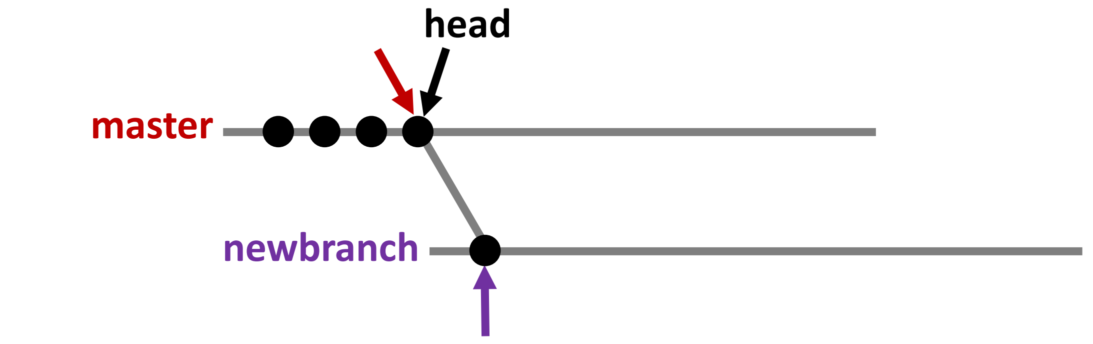
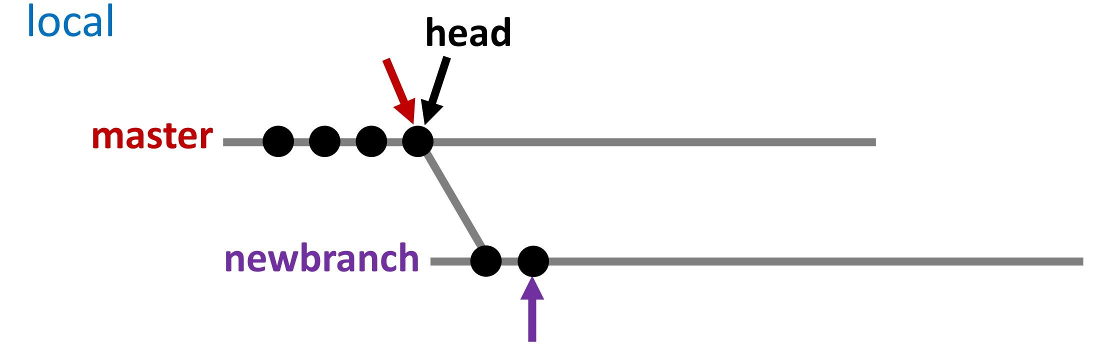


remote

local



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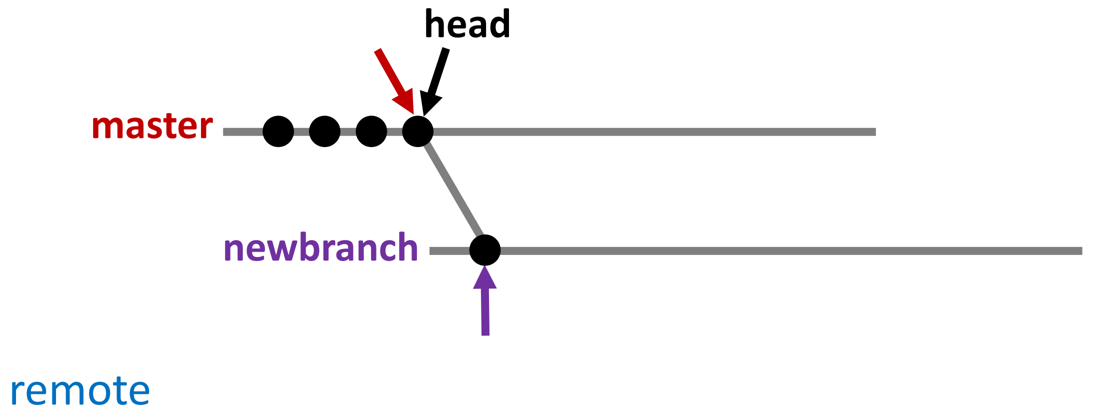

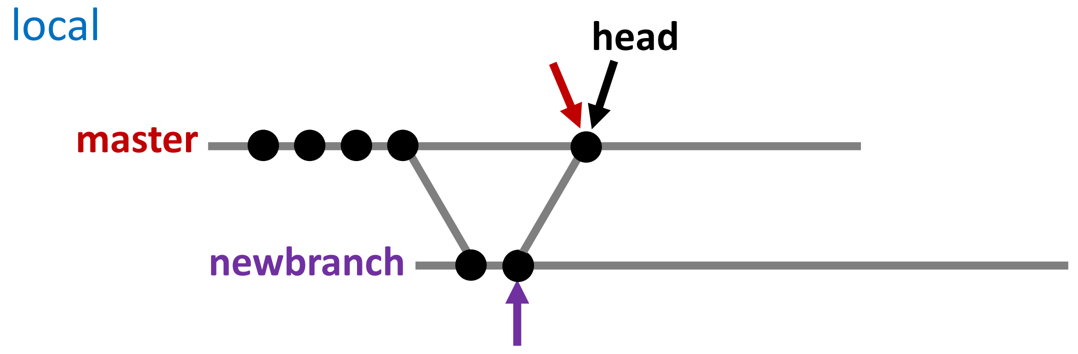

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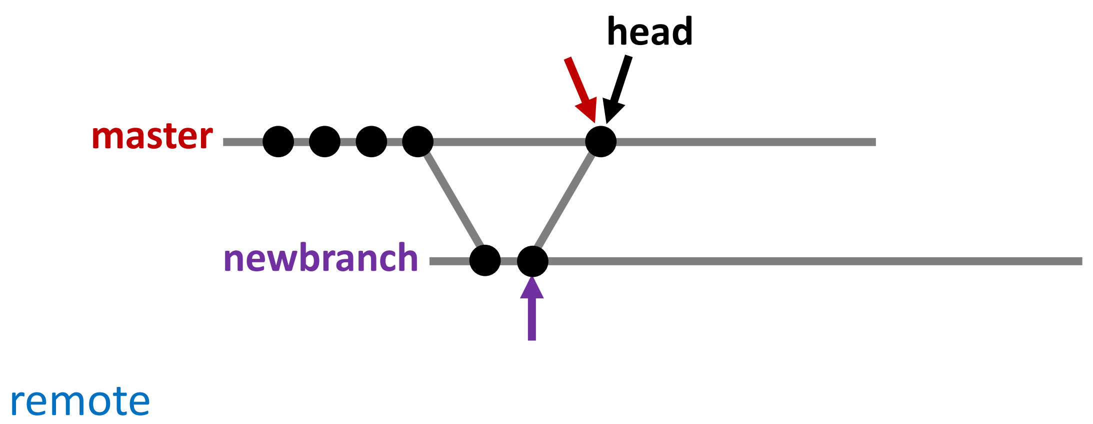

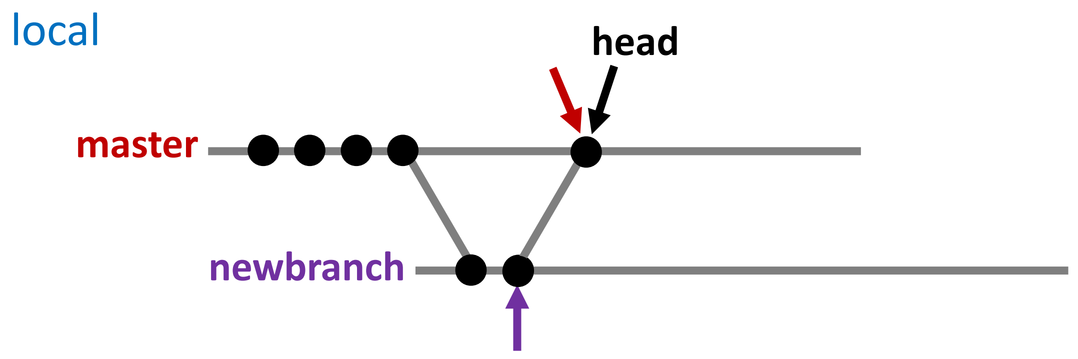

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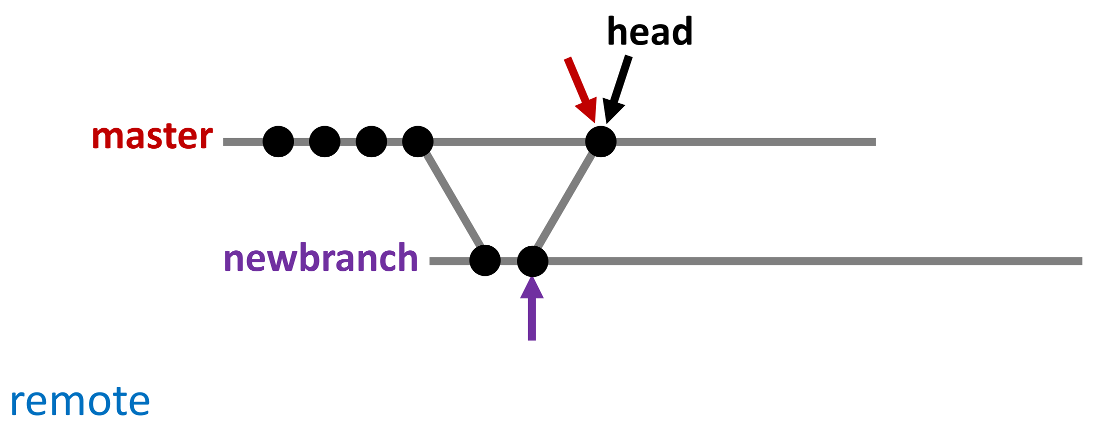

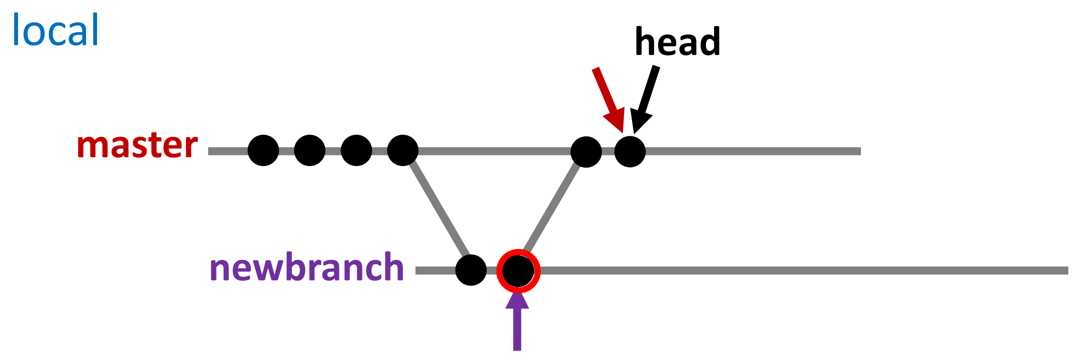

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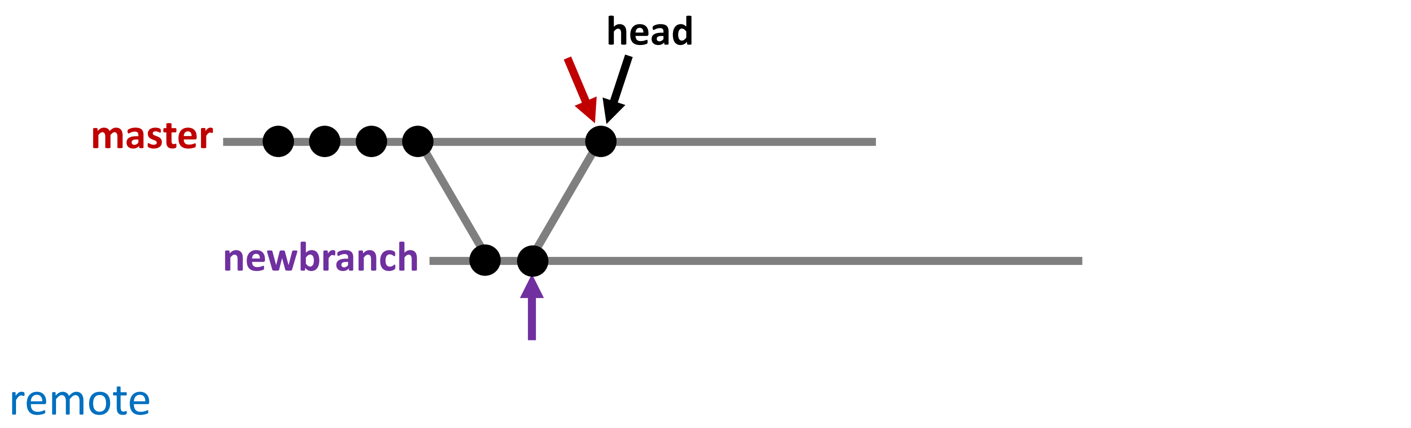

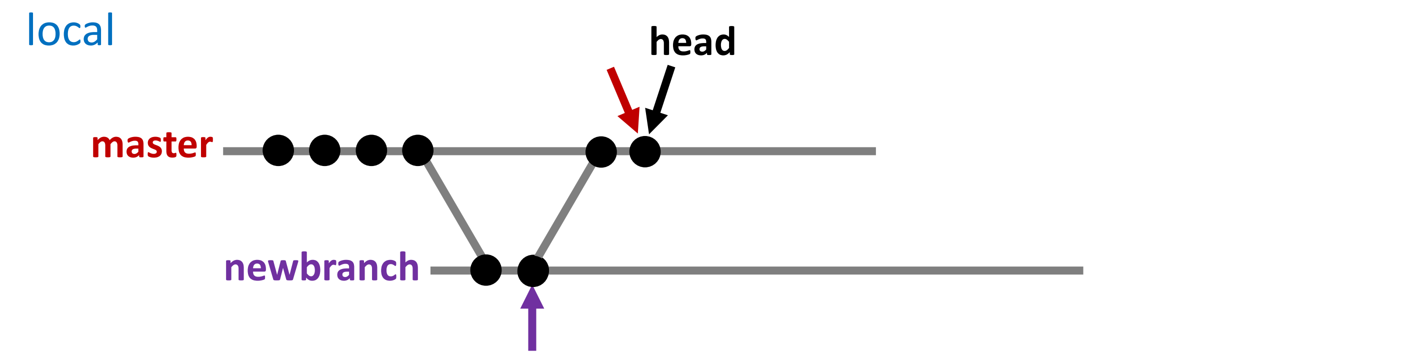

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> git commit –m “Updated test.txt + todo.txt”
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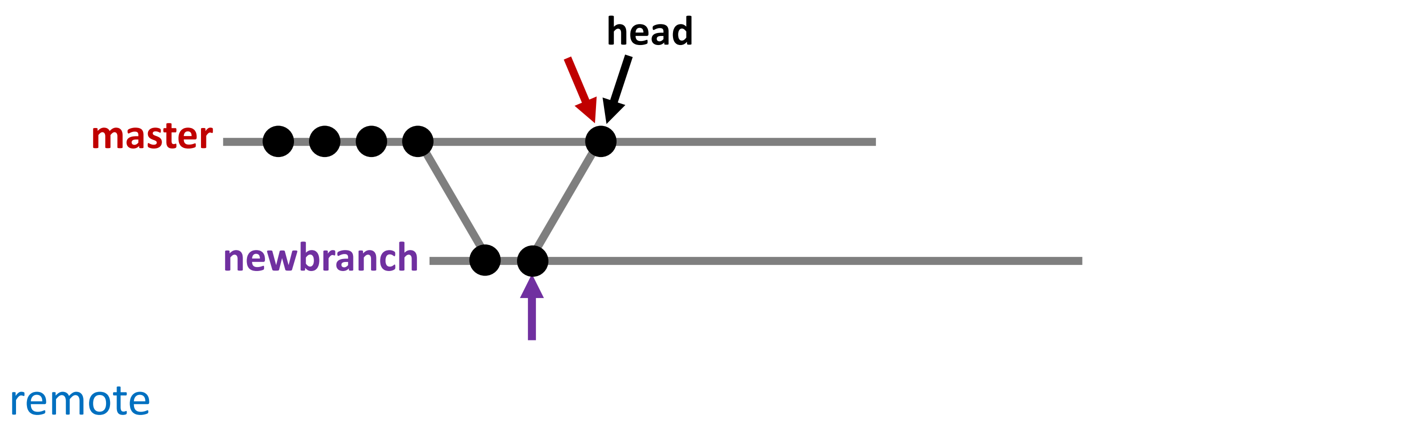
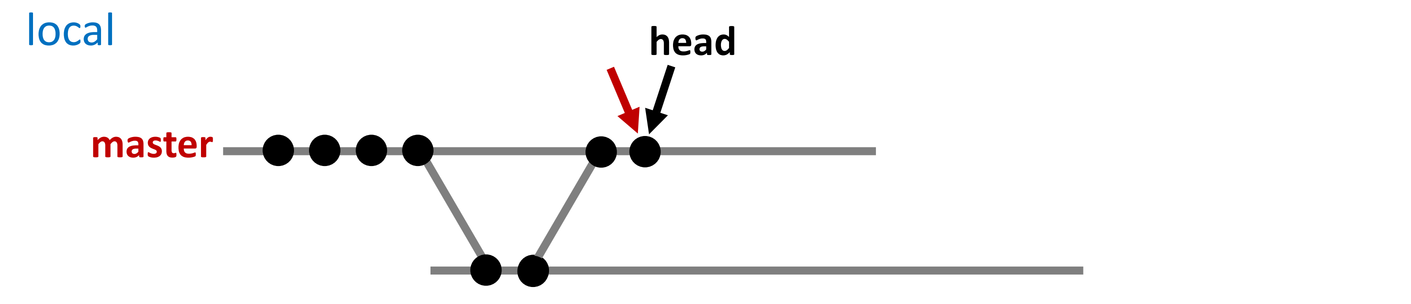
> git push
> git revert <commit-id>
> git branch –d newbranch
>
```





Changes for Commit: Changed Files: Untracked Files:

*** Forking vs Cloning ***

VS

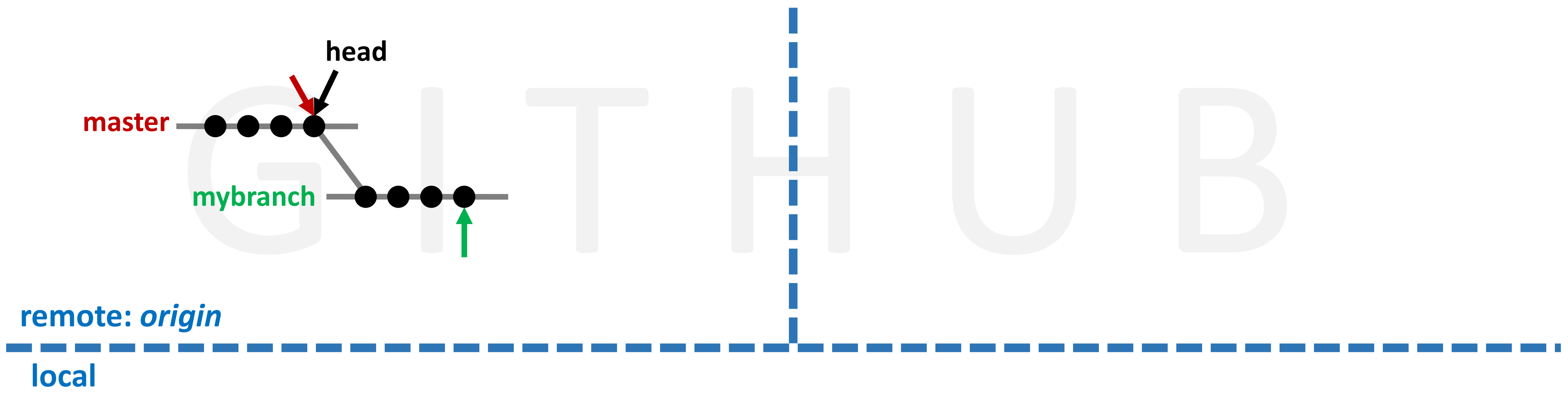
*** Forking vs Cloning ***

- **Fork** – a **remote** copy of a **remote repository** at a certain point in time
  - A **GitHub** construct (e.g. applies to all public **remote repositories**)
  - **Ex.** Making a *copy* of someone else's **GitHub** [remote] repository in *your* **GitHub** account
  - All public repositories on **GitHub** can be **forked**

- **Clone** – a **local** copy of a **remote repository** at a certain point in time
  - A **Git** construct (independent of **GitHub**)
  - All public repositories on **GitHub** (including **forks**) can be **cloned** to a **local repository**
  - You can always **push** to your **fork**, but you might not have permission to **push** to an arbitrary **repo**

- **Collaborative Workflow:**
  1. Create a **fork** of a **project or repository** that you want to contribute to in **GitHub**
  2. **Clone** your **fork** to your **local repository** (refer to your **fork** as **origin**)
  3. Add the original **remote repository** to your **local repository** (refer to this as **upstream**)
  4. **Pull** changes from **upstream** and **push** changes to **origin**
  5. When you are ready to make your changes available to the original **remote repository**, create a **pull-request** from your **fork**
  6. Repeat steps (4) – (5)

*** Forking vs Cloning (Visualized) ***



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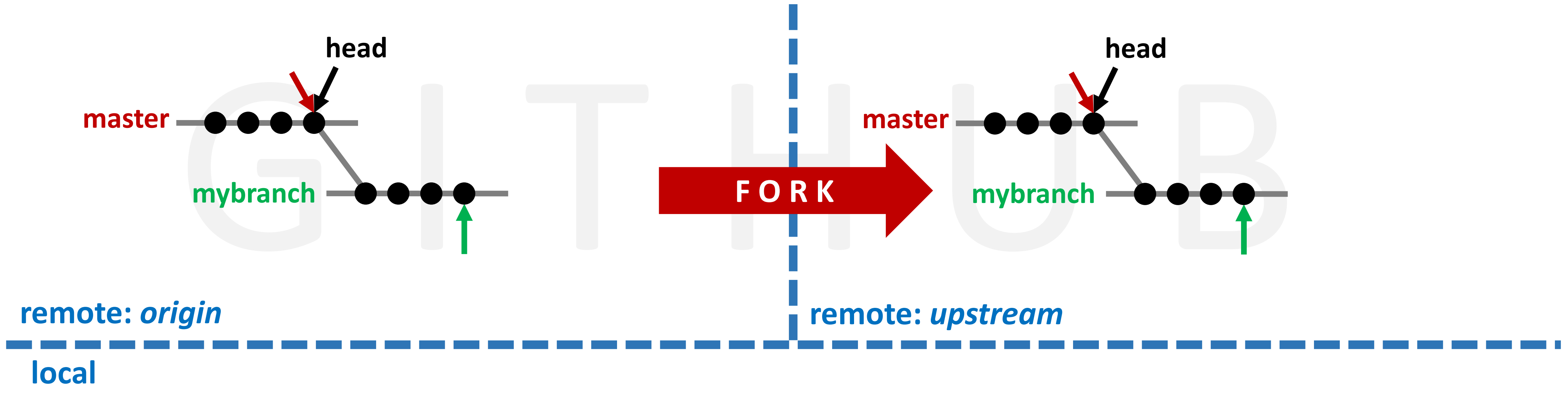

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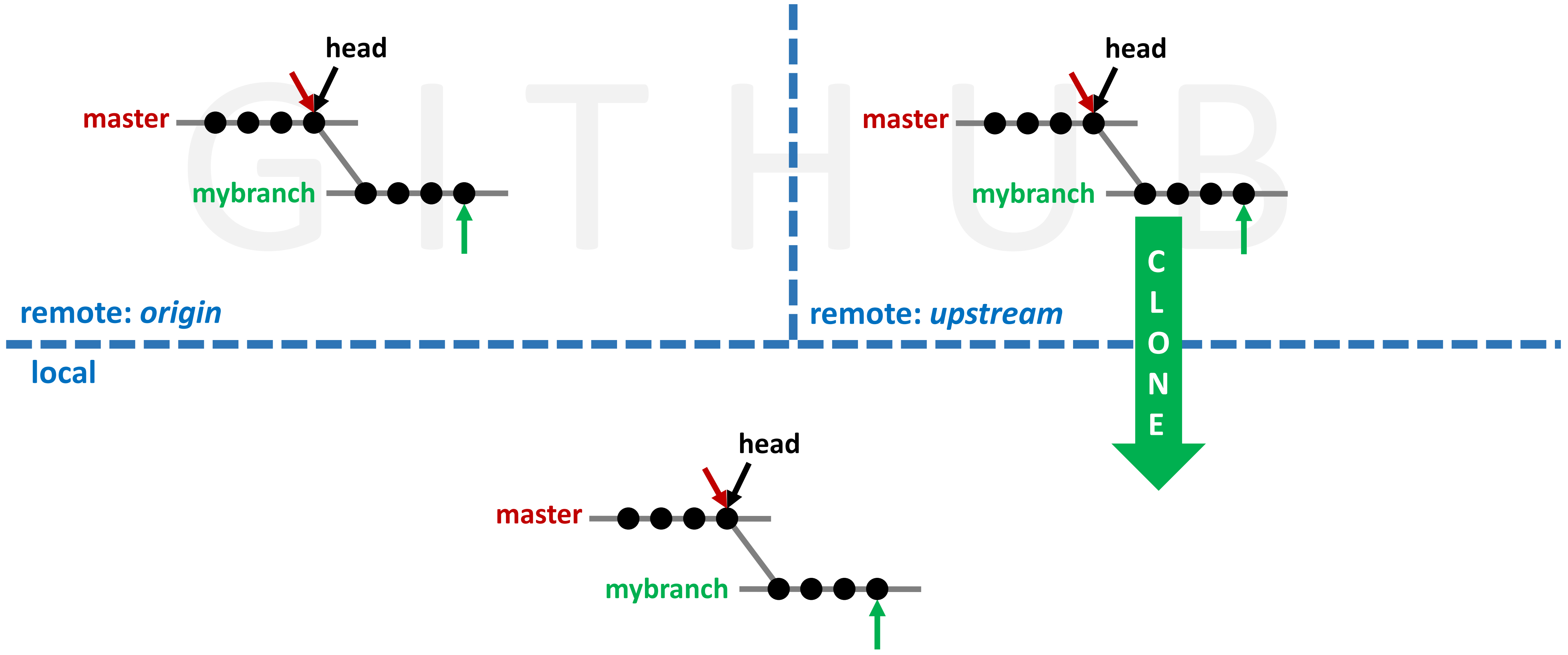

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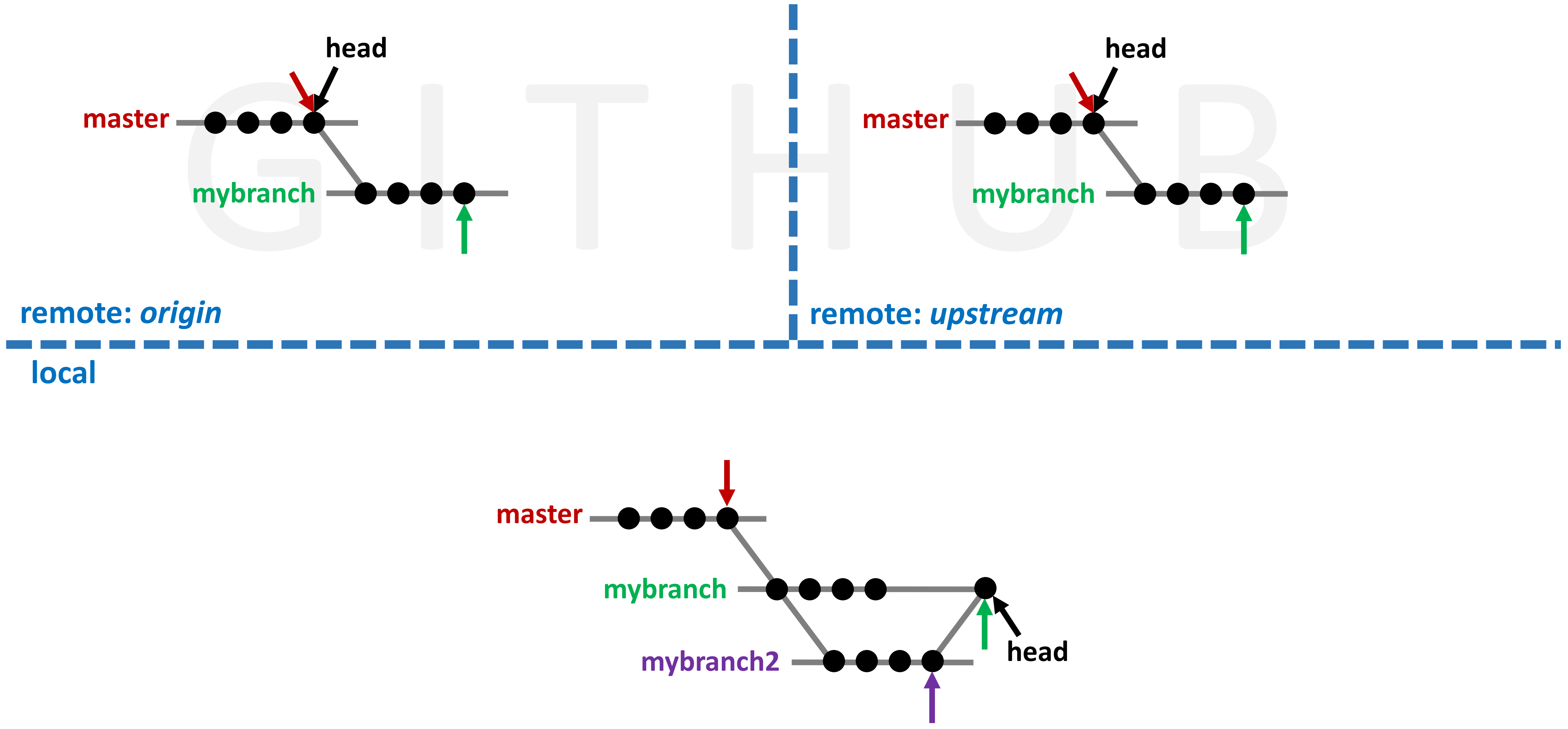

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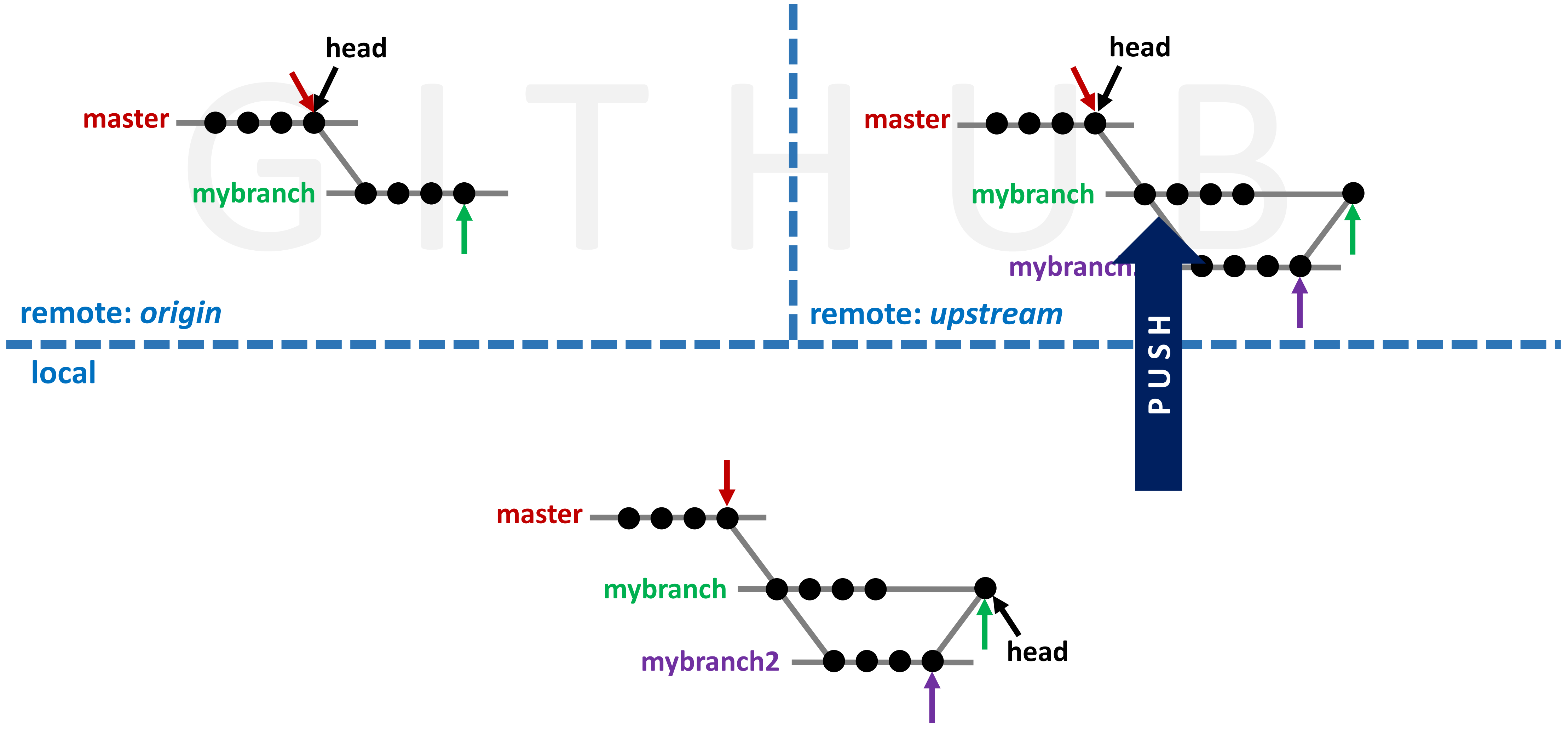

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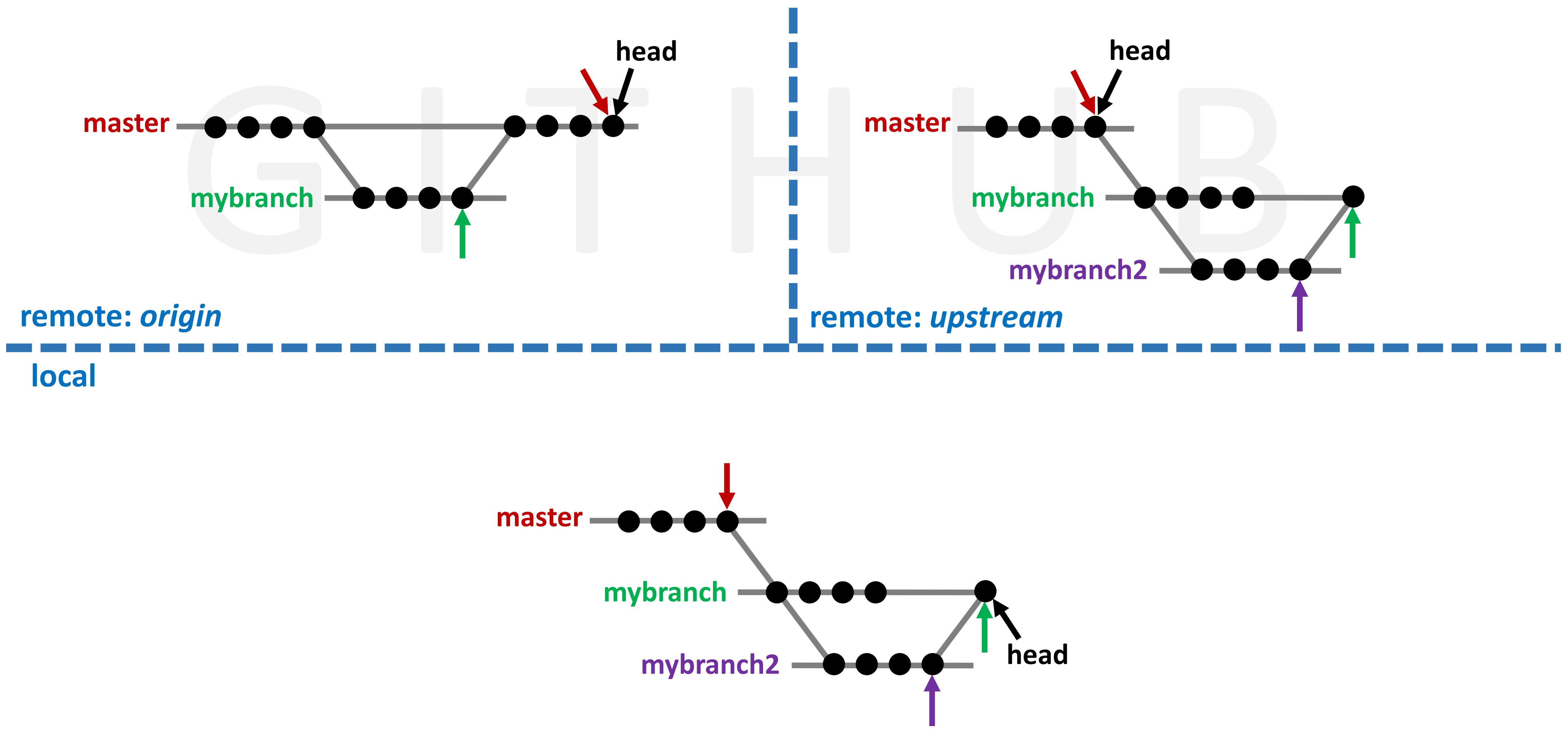

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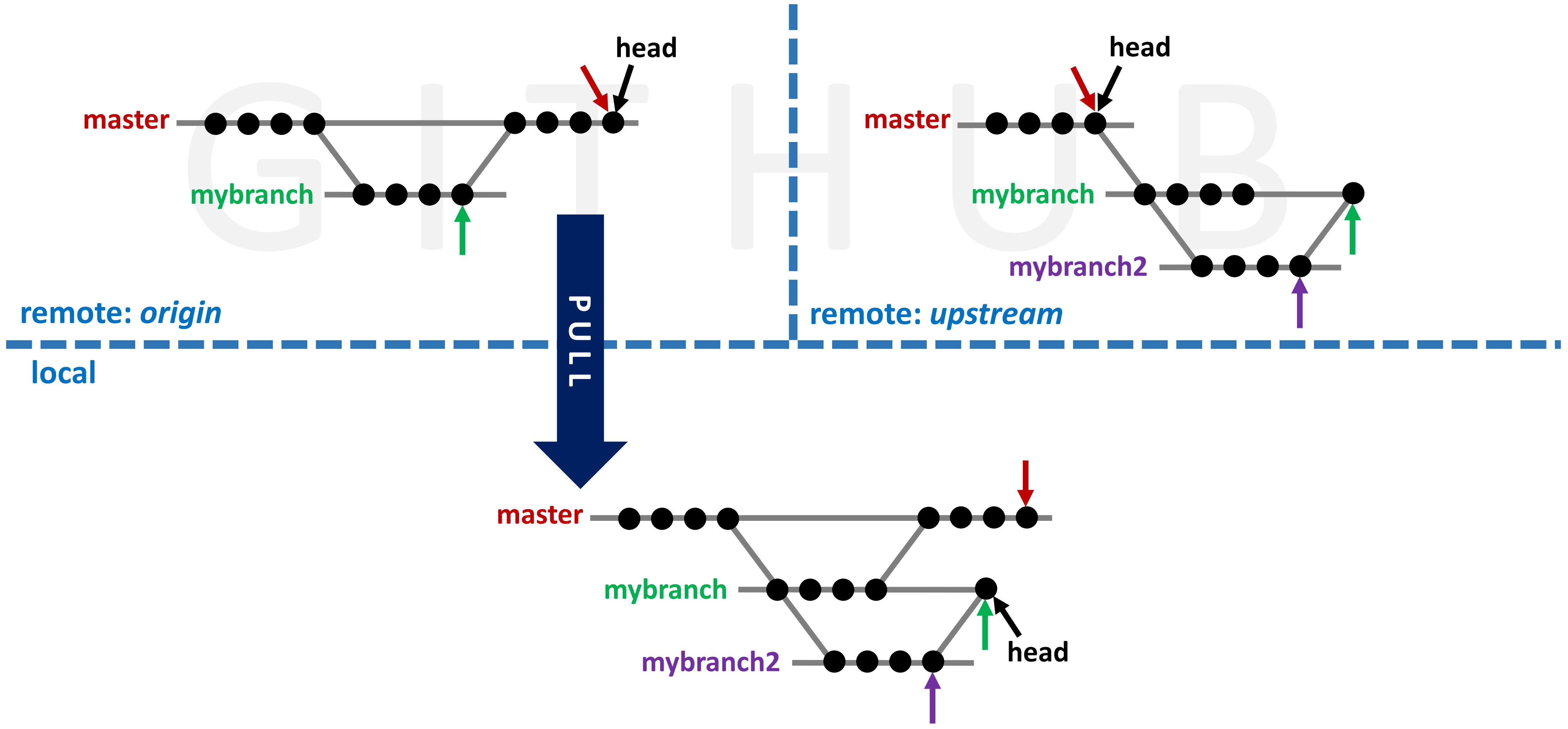

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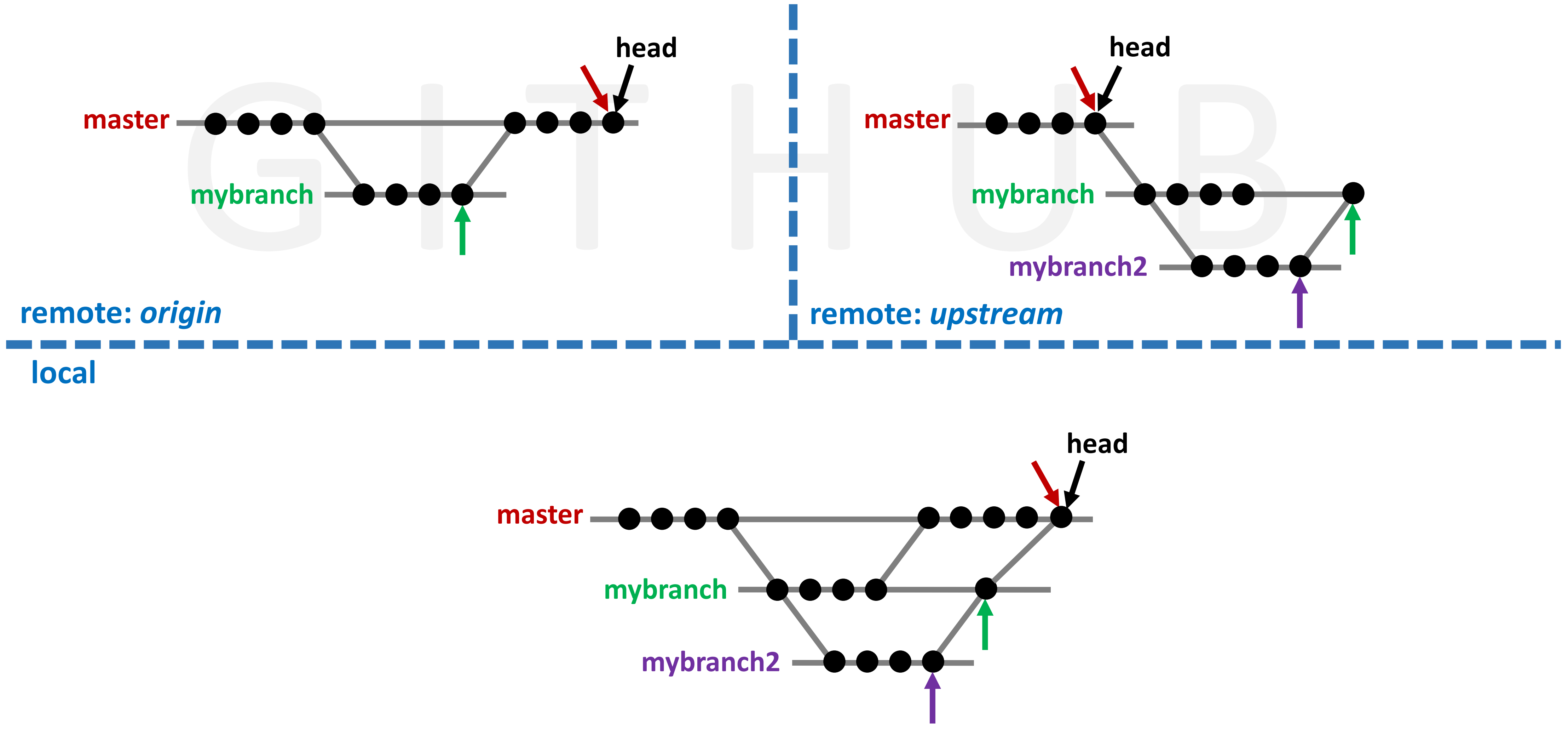

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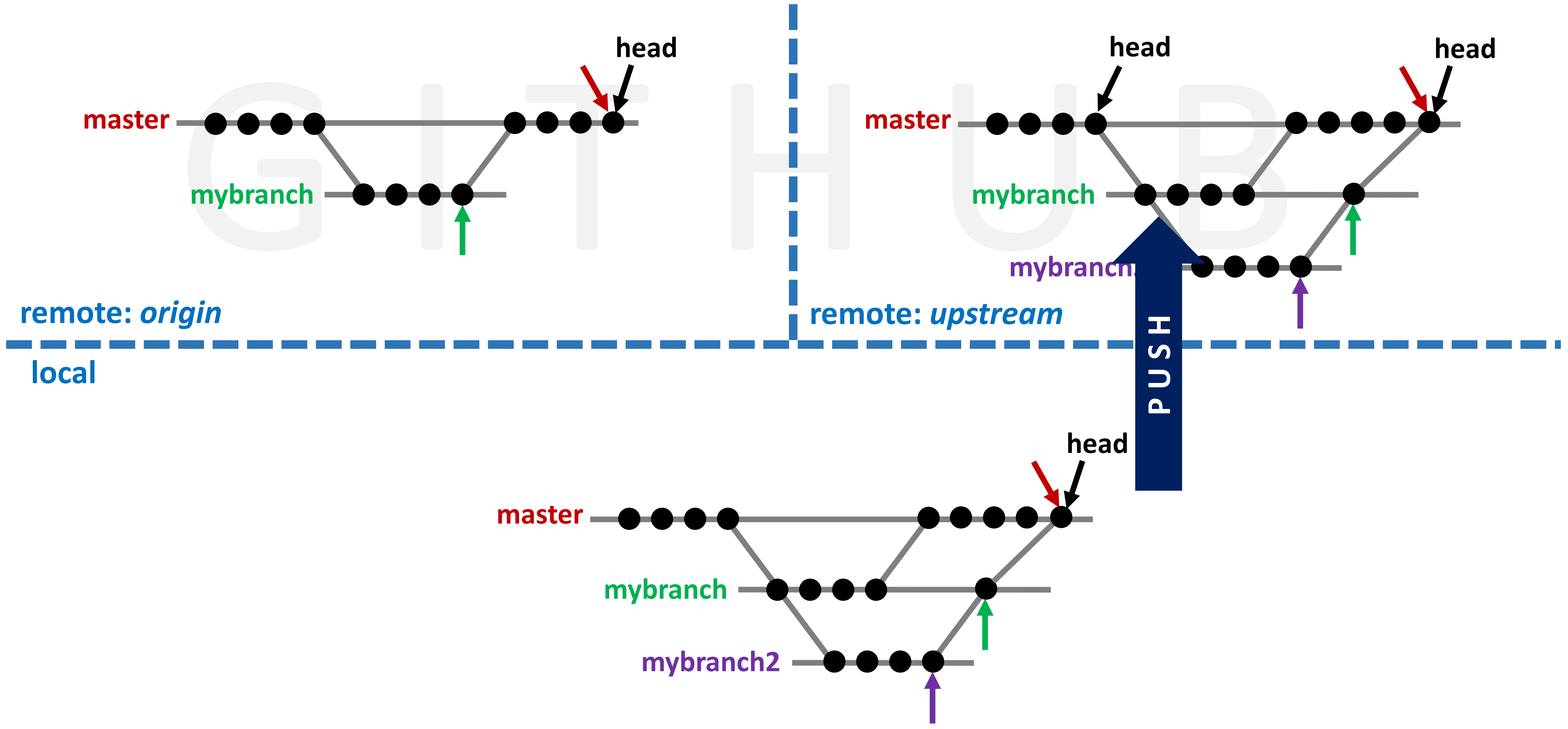

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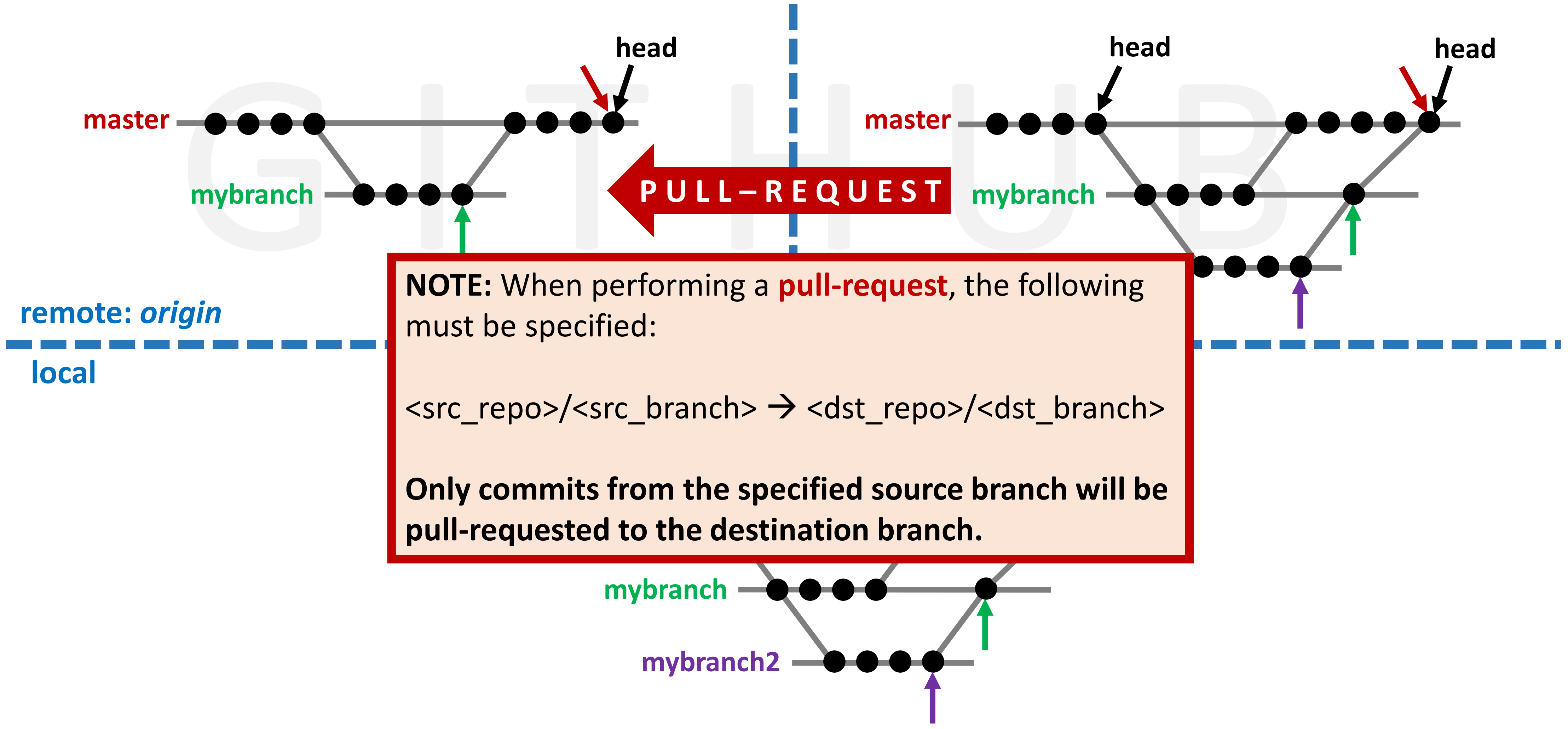
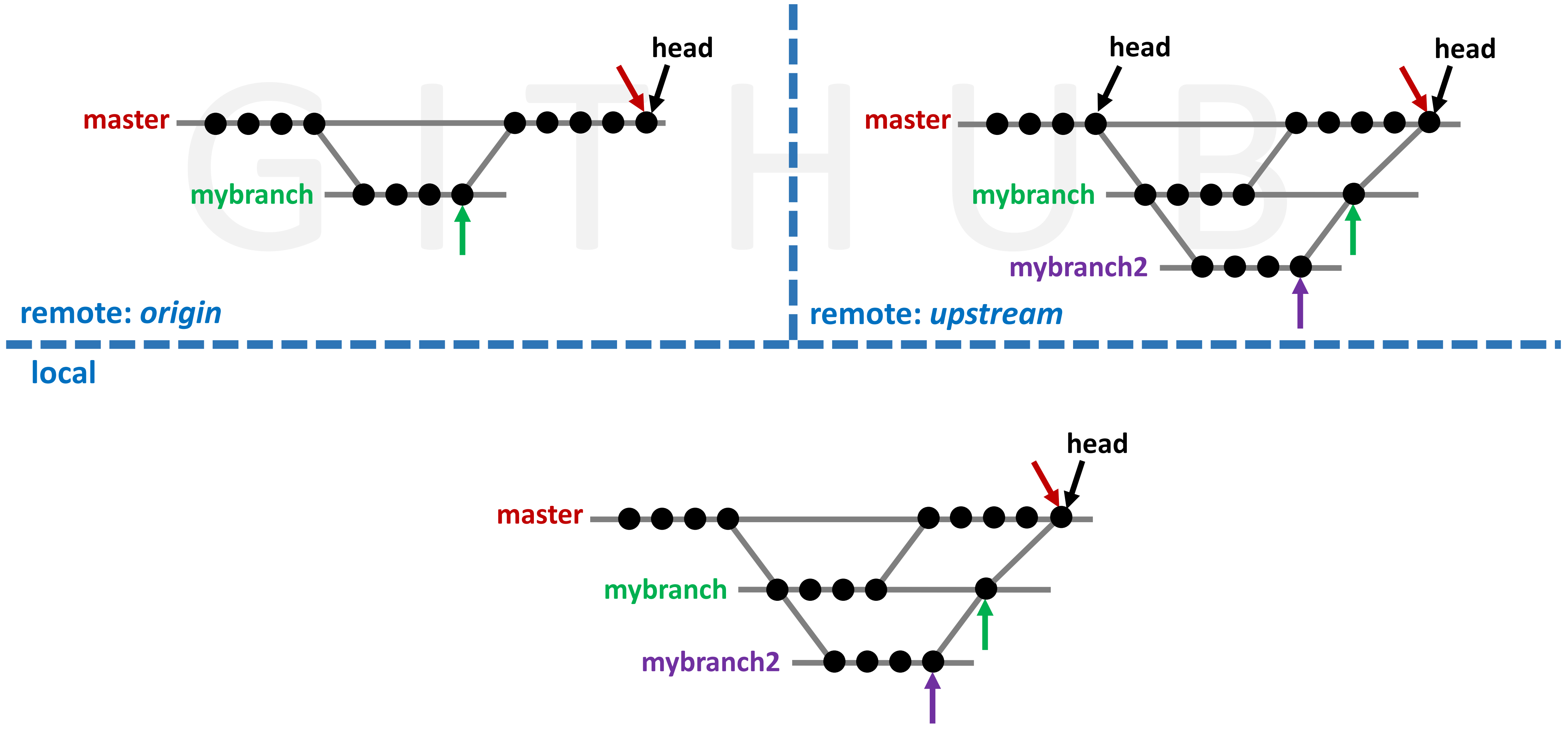


NOTE: When performing a **pull-request**, the following must be specified:

<src_repo>/<src_branch> → <dst_repo>/<dst_branch>

Only commits from the specified source branch will be pull-requested to the destination branch.

*** Forking vs Cloning (Visualized) ***



5. Getting Set-Up with Git

1. If you haven’t already, you will need to do the following:
   - Install Git on your computer
   - Create an account on GitHub

2. Fork a repository on GitHub, make changes, and generate a pull-request

3. Create a public/private repository on GitHub and practice the Git workflow

6. Topics Not Covered…

The topics listed below slightly **advanced** and have not been covered. They considered **advanced** because they involve **changing history**. They can have **dangerous** consequences if applied improperly.

- **Rebasing** or **squashing** commits
- **Resetting** commits (at various levels)
- **Force** pushing commits to branches in remote repositories

NOTE: The above topics are not necessary to use Git, although they may provide some convenience in certain situations… All required topics have already been addressed in this presentation.

Useful References

- **Official Git documentation**
  https://git-scm.com/doc
- **Git downloads (Windows / Mac)**
  https://git-scm.com/downloads
- **Git/GitHub Guide: A Minimal Tutorial**
  https://kbroman.org/github_tutorial
- **A statistician's initial experiences of Git/GitHub**
  https://thestatsgeek.com/2015/05/16/a-statisticians-initial-experiences-of-gitgithub

Questions?