Lecture 05 – Tools of the Trade

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NERS/ENGR 570 - Methods and Practice of Scientific Computing (F22)

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Outline

- Version Control w/ Git
- Some IDE's, Advanced Editors, and Graphics in Linux
- Class exercise with Git and Make

Learning Objectives: By the end of Today's Lecture you should be able to

- *(Value) Understand why we should do version control*
- *(Knowledge)* What are the components of an integrated development environment, and what are some examples.
- *(Skill)* Working on a distributed software project using git and Make
- *(Knowledge)* Basic concepts in git

Version Control

What is Version Control?

- A way of tracking detailed changes in source code over time.
  - e.g. what changed? when did it change? who changed it?
- Version control is an ***essential*** component to software development.
  - Has been used by software developers for decades
- Version control is generally performed using an external program.
- Version control is applied to a "repository".
  - Source code lives in one (or more) *respositories* (e.g. repos) available to team members/contributors.
- A repo is a computational scientist's laboratory notebook.
  - Like a laboratory notebook, it is only useful if it is used properly.
- Also known as: "source code control", "revision control", "source code versioning"

Slide source: Best Practices for HPC Software Developers – Session 3: Distributed Version Control and Continuous Integration Testing

What version control does

- Establishes a common context for code contributions and the exchange of ideas
- Establishes a chronological sequence of events
  - A single change is commonly referred to as a *commit*
- Serves as “truth” for a software project
- If you don’t have a “tangible” common reference for your source code, *there is nothing for your team to discuss*.
- Results from uncontrolled code are (generally) *not reproducible*.
- Recall your most frustrating document-sharing experience...
  - ...and imagine it continuing for months... or years with the people involved changing and the document getting larger and larger.
  - (it doesn’t work)

Utility of Version control

- What if I program by myself?
  - Still offers same advantages.
    - Try to remember the steps you took to complete a homework assignment in high school.
  - Working on different machines is no problem.
  - If you eventually want to collaborate with someone then there's no extra work!
- Can I use version control for other things?
  - YES!
  - Most version control programs are excellent for text files. Working with binary files, its not so good.
  - You may not think its worth the extra effort now, but your future self will thank you.
    - Commonly used for LaTeX documents.

Version Control and Versioning

Version Control v. Versioning

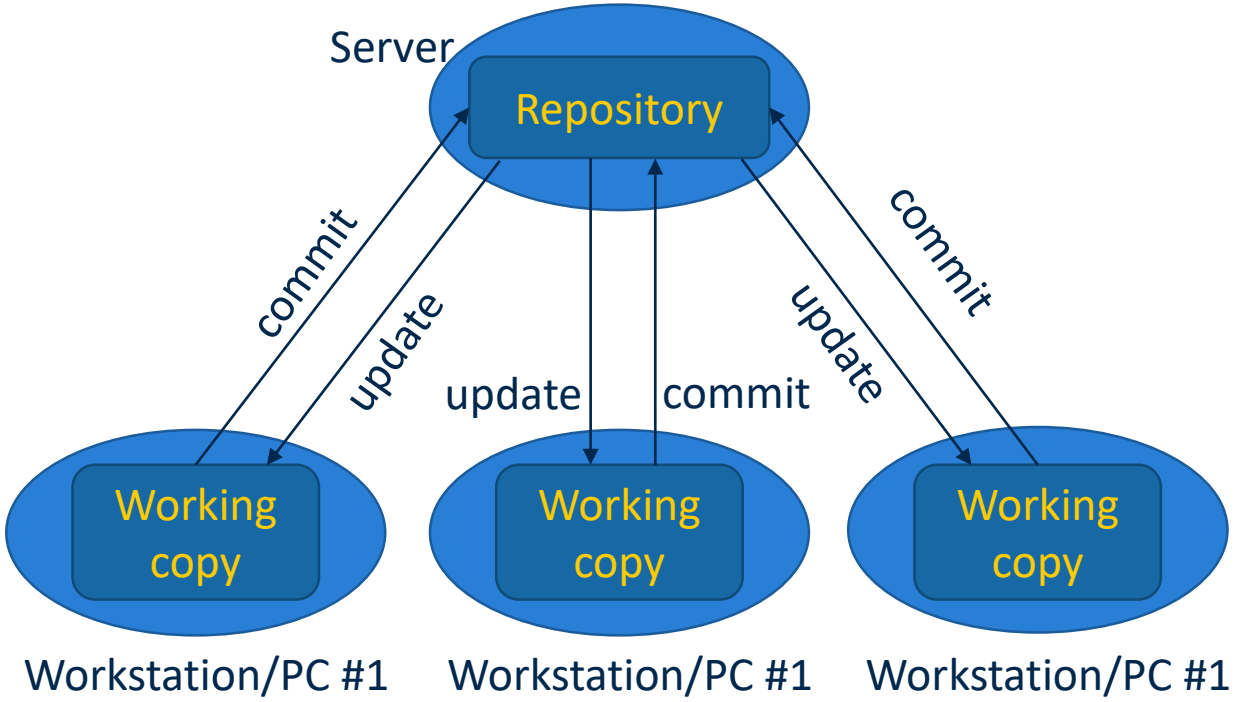
- Version control allows you to define and publish a specific version of the code. (e.g. one specific commit)
- Versioning is a popular description for how to describe a version and what it means is defined here:
  - http://semver.org/
  - Short for “Semantic Versioning”

Short Definition from http://semver.org/

- Given a version number `MAJOR.MINOR.PATCH`, increment the:
  - `MAJOR` version when you make incompatible API changes,
  - `MINOR` version when you add functionality in a backwards-compatible manner, and
  - `PATCH` version when you make backwards-compatible bug fixes.
- Additional labels for pre-release and build metadata are available as extensions to the `MAJOR.MINOR.PATCH` format.
- Extensions beyond this:
  - `MAJOR.MINOR.PATCH-custom`

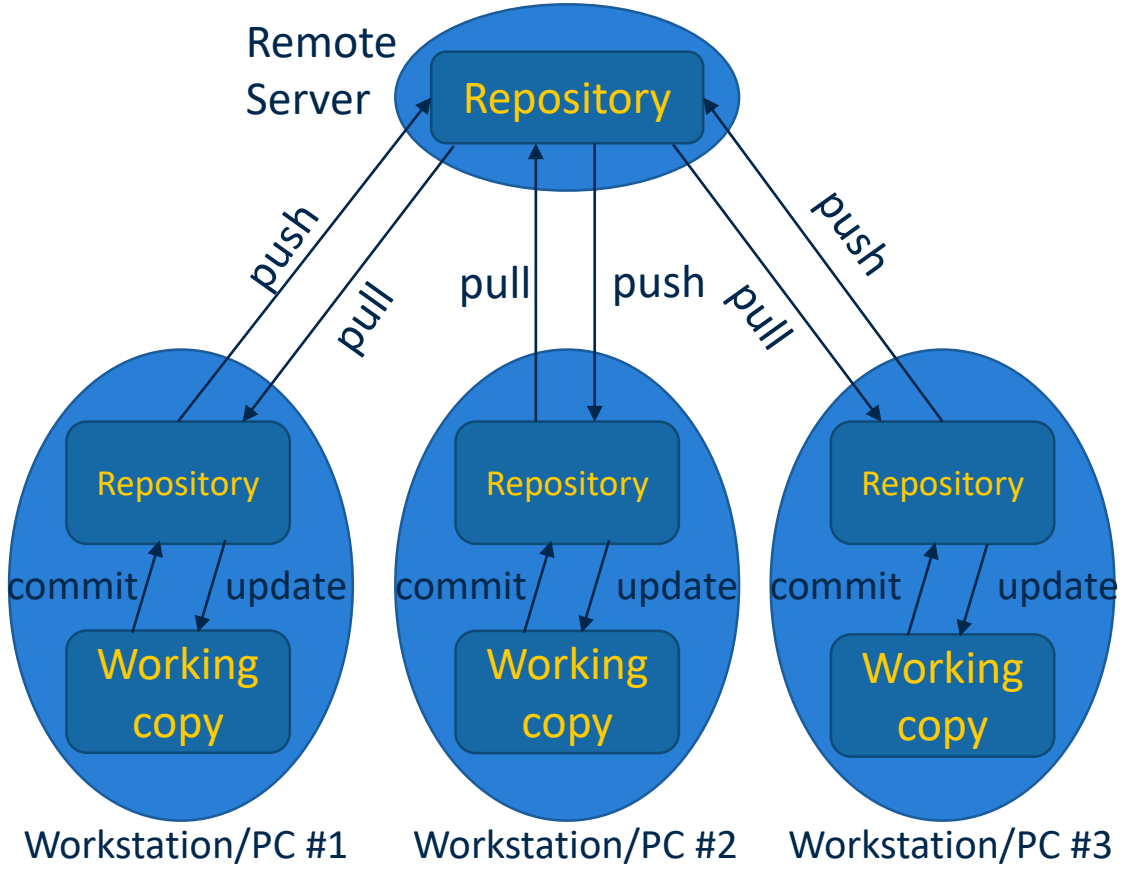
Models for Version Control Programs (1)

- Simple: “Centralized” Version Control
  - There is one repository containing the “master” version (or “trunk”) of the source code
  - Everyone syncs with this repository
    - e.g. *checks out* files, *changes* them, and *commits* these changes.
  - Requires that people must cooperate/coordinate to make sure their changes don’t conflict with each other.
  - Limited in capability to create development branches.



Models for Version Control Programs (2)

- Modern: “Distributed” Version Control
  - Everyone has an entire copy of the repository (and history!)
  - There is a “main” repo agreed upon by convention
  - People typically work in development branches with isolated changes until ready to merge
  - Allows for more flexibility for design and development procedure



Open Source Tools for Version Control

Centralized Version Control

- Concurrent Version System (CVS)
  - One of the first. Don't recommend you start here.
  - Should not need to work with it
    - There are many tools to migrate a CVS repository to a newer one.
- Subversion (SVN)
  - Modern successor to CVS
  - Supports branching

Distributed Version Control

- git
  - Probably the most popular version control program
    - Written by same person who wrote linux.
  - Several programs built around git offering different interfaces
    - gitlab, github, gitorious
- Mercurial (hg)
  - favors ease of use
  - syntax similar to subversion

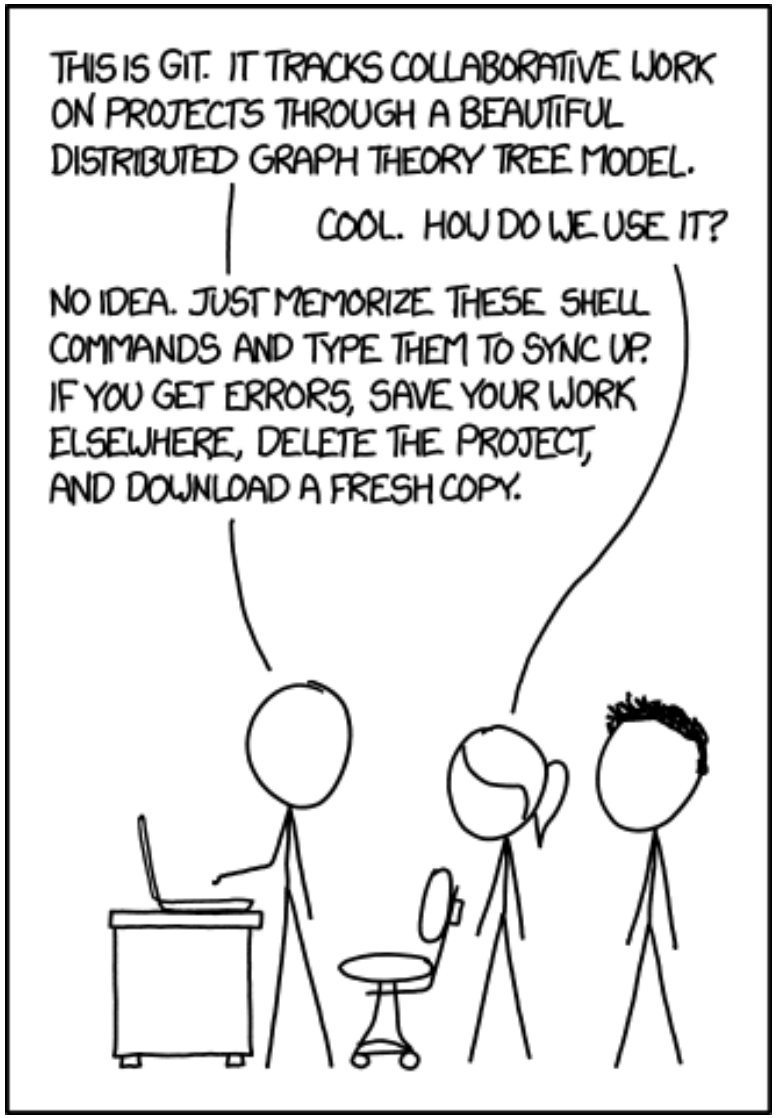
Version Control Disclaimer

- It's a tool, and its only as good as its user.
- It does not define a *development process*
- Up to you to choose an approach that best works for you and your team
- Identifying and using good software development processes is hard.
  - That's why we'll talk about it in a future lecture

http://xkcd.com/1296/

A little about git

- Initially released in 2005
  - original author was Linus Torvalds (the linux guy)
- Difficult to learn without putting in some time
  - That's what the demo is for!
- It is difficult to learn without understanding the underlying concepts.
- Teams that use git well often have an expert.



https://xkcd.com/1597/

Common Nomenclature in Git

- *Repos* – repositories. the full history of the project
- *Clones/cloning* of repos – making a copy of
- *Commits/committing* within repos – making code changes
- *Branches/branching* within repos – isolated development
- *Remotes* – references to other repos on other machines
- *Pulls/pulling* – incorporating changes from another repo to your local repo
- *Pushes/pushing* – publishing changes from your local repo to another repo
- *Revisions* – also known as commits, can be referred to by a the SHA-1 (e.g. 1e95a651f4aeea1aa00173347f254dfb93ae350a)
- *Workspace* – local state
- *History* – the graph, specifically a directed-acyclic-graph (DAG)

Infrastructure Tools

Now you know how to track changes
What's next?

Integrated Development Environments

What do they offer?

- Browse file system / Navigate source
- Edit Source
- Compile and Link code
- Debug code (usually interactively)
- Interact with a version control system
- Enable some automation
- Profilers
- Static Analysis
- Inline help (tooltips)
- Package management (sometimes)

Some examples

- Microsoft Visual Studio (C/C++/Fortran/others)
- Eclipse (Java/C/C++/Fortran (kind of))
- Spyder (Python)
- Atom (Lots)
- Visual Studio Code (Lots)
- NetBeans (Java)

Working with IDE's in Linux

(GNU) Make

- Likely the most popular tool for defining executables and compiling software in Linux
  - Alternatives: Ninja, Tup, Gulp
- Standard in Linux/Unix
- CMake generates makefiles for you
  - It can also generate inputs for other build tools
  - Gives you fancy features
    - parallel, percentage complete, default targets, help, coloring.

- Makefiles must define targets using rules **(INDENT WITH TABS)**
  - Can also define variables, use include

```
target ... : prerequisites ...
          recipe
          ...
```

```
edit : main.o kbd.o command.o display.o \
       insert.o search.o files.o utils.o
       cc -o edit main.o kbd.o command.o display.o \
       insert.o search.o files.o utils.o

main.o : main.c defs.h
       cc -c main.c
...

clean :
       rm edit main.o kbd.o command.o display.o \
       insert.o search.o files.o utils.o
```

Examples from GNU Make manual: https://www.gnu.org/software/make/manual/make.html

https://cmake.org/

What is it?

- Open source
- Cross platform (truly)
  - Supports multiple build tools, toolchains, & environments.
- Includes
  - CMake – configuration tool
  - CTest – testing tool
    - automates testing and collection and publishing of test results
  - CPack – generates installers
  - CDash – Web interface for viewing test results

Software Projects Using CMake

- CGAL
- Geant4
- GROMACS
- Trilinos
- VTK and Paraview
- zlib
- LAPACK
- HDF5
- Netflix

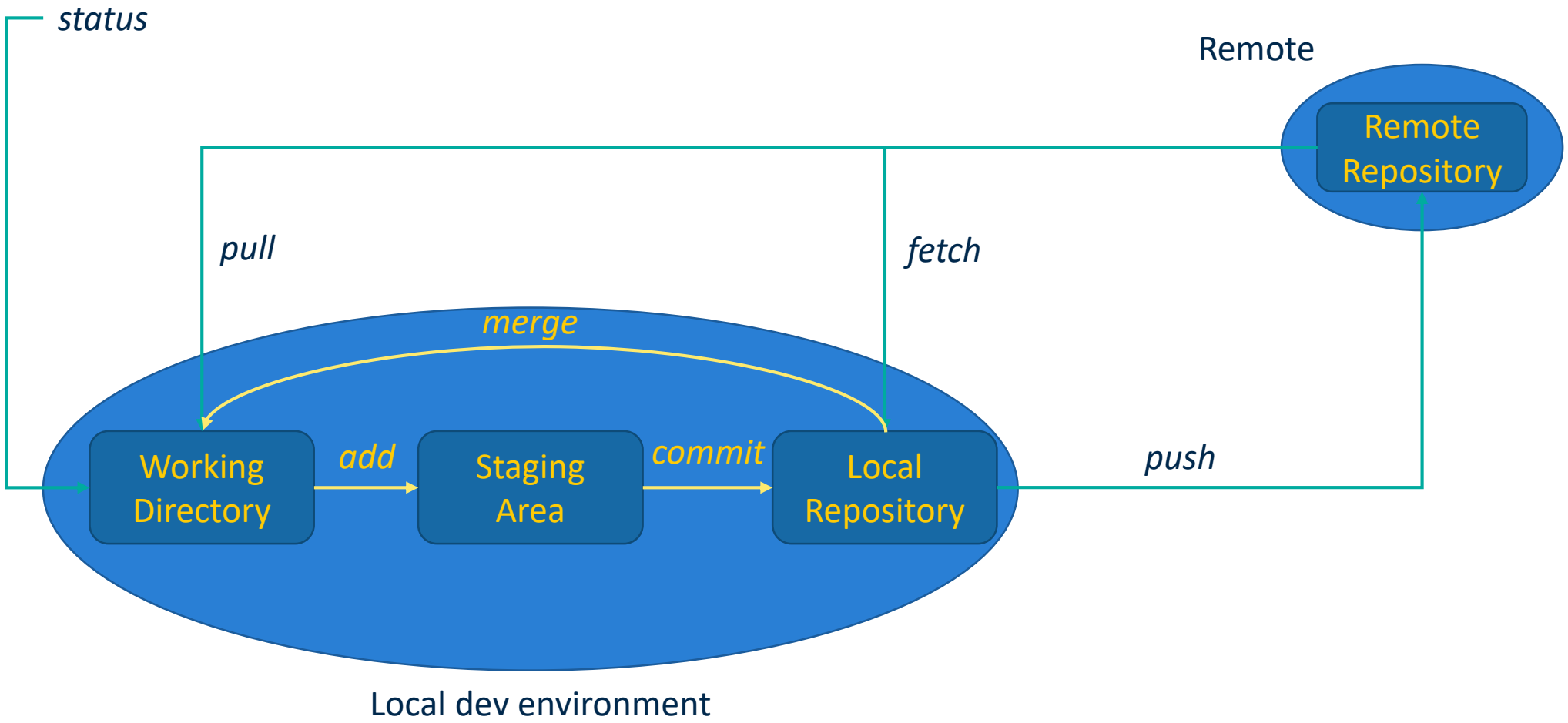
Class Hands-on Activity

Git Concepts

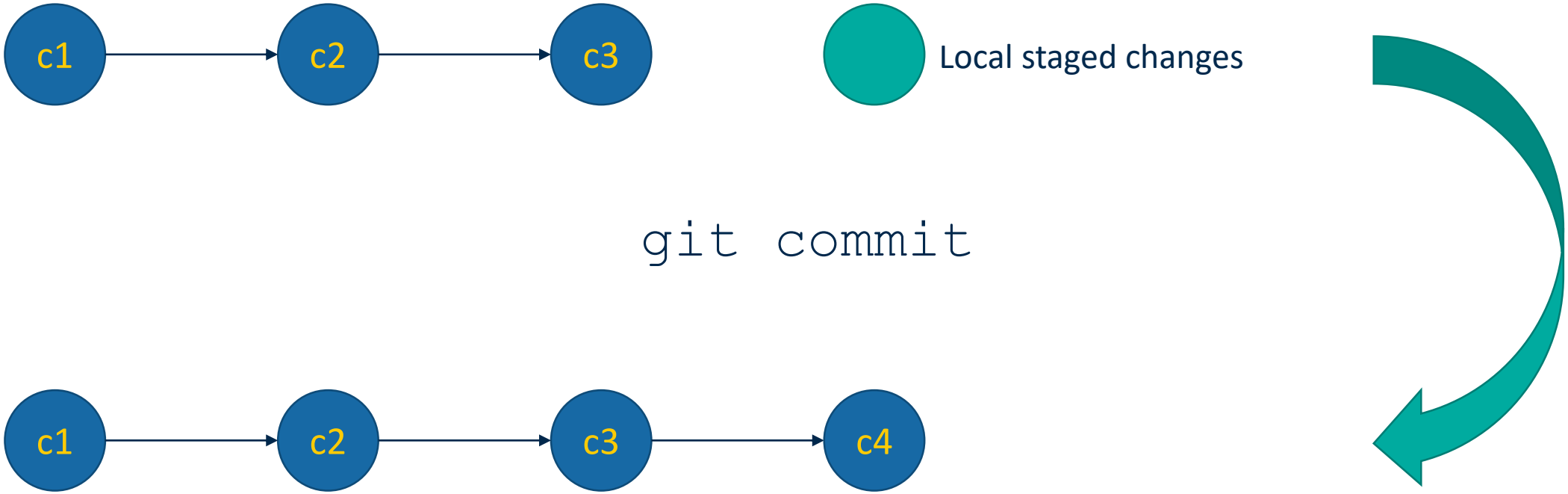
https://learngitbranching.js.org/

https://ideas-productivity.org/resources/howtos/git-tutorial-and-reference-collection/

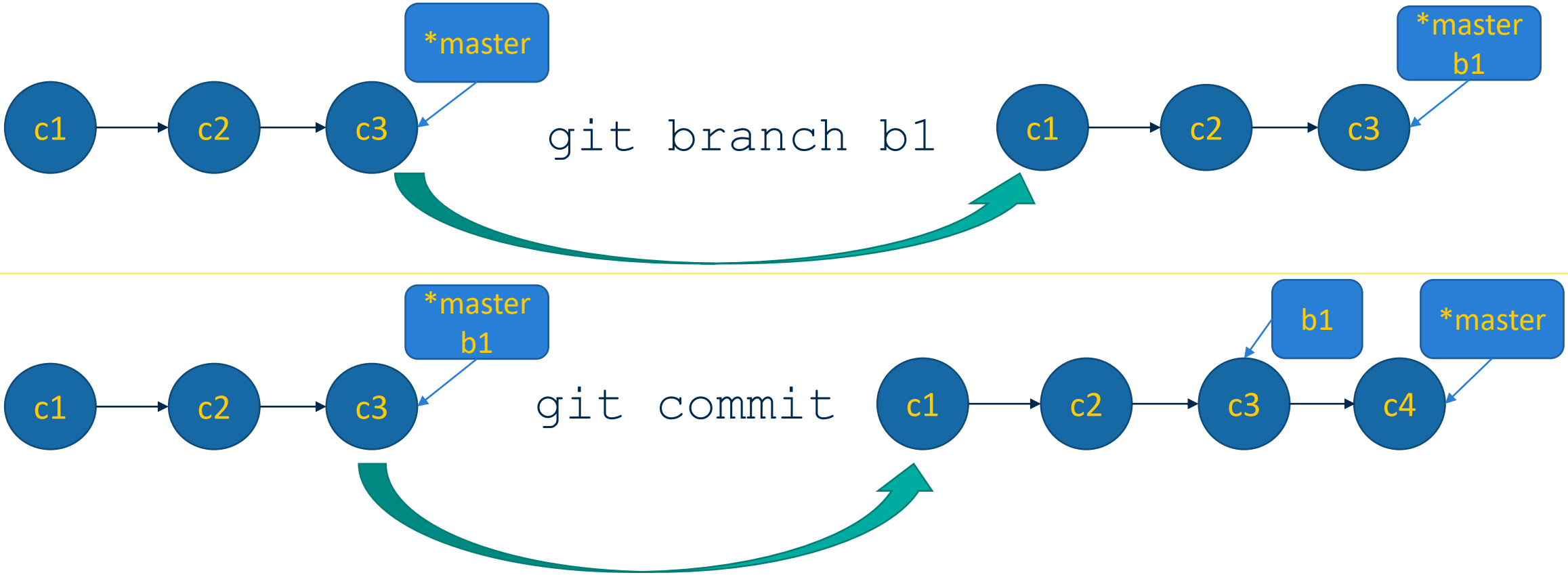
Overview of Git Concepts



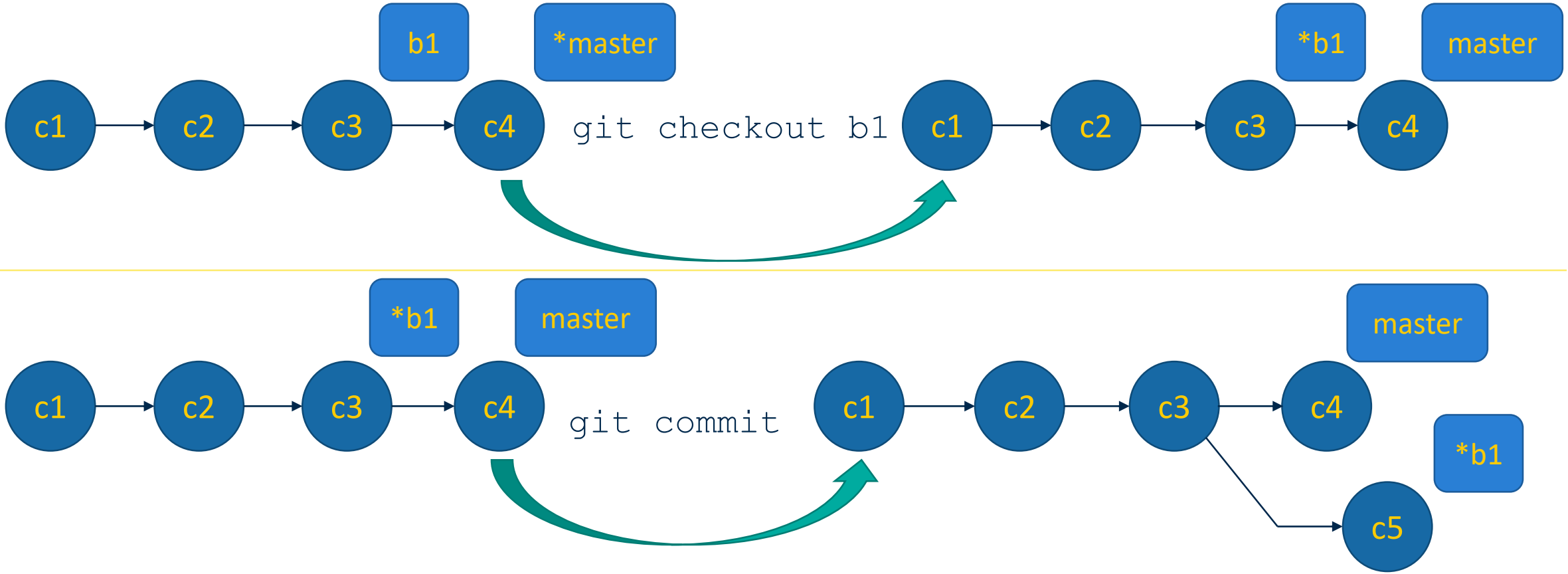
git concepts: commits



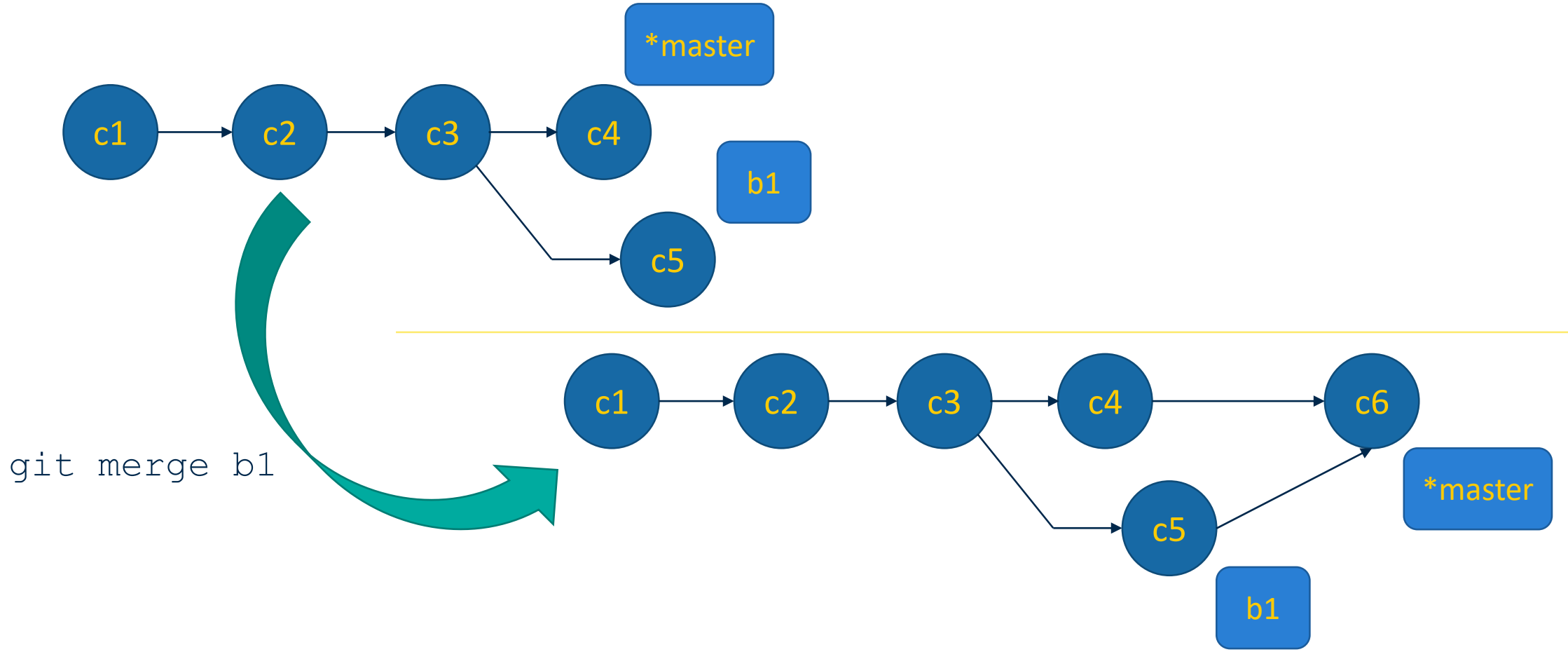
git concepts: branches (1) – creating a branch



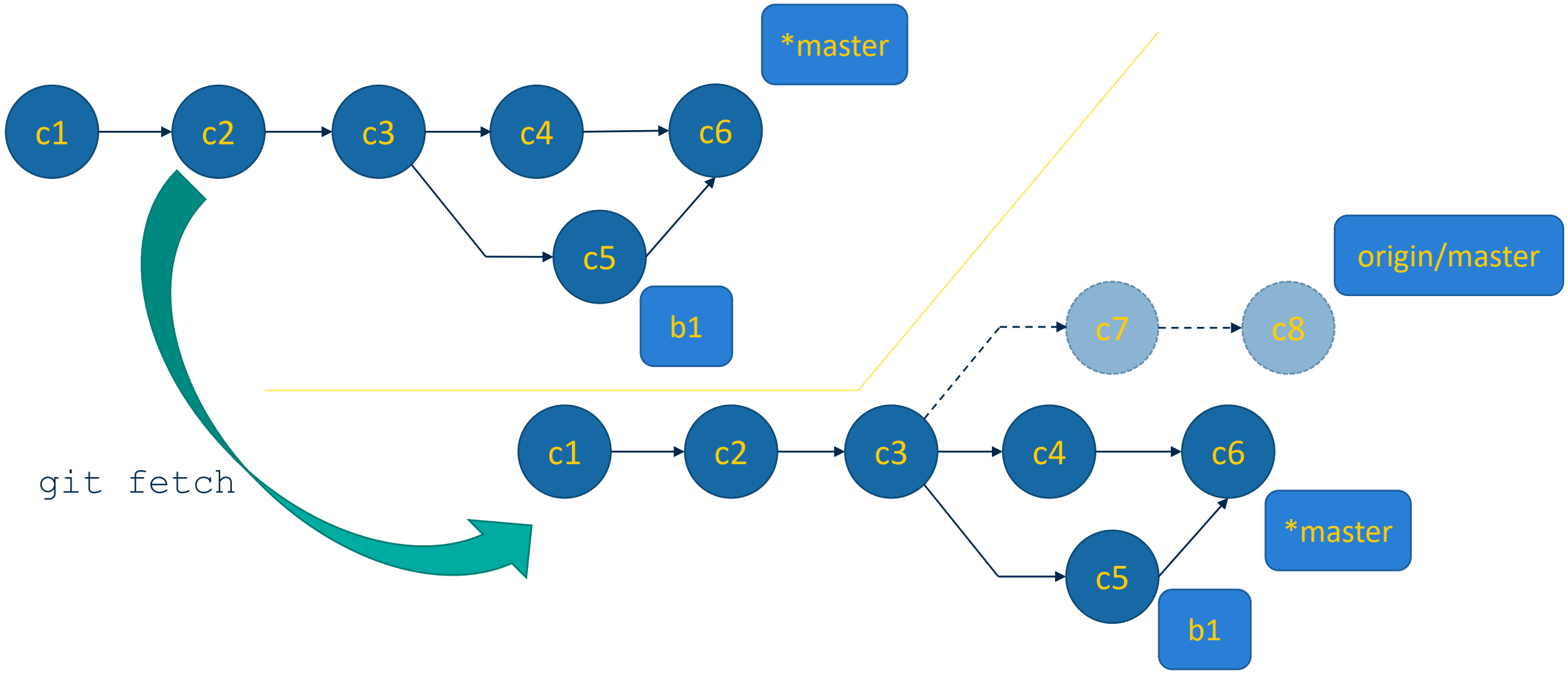
git concepts: branches (2) – working on a branch



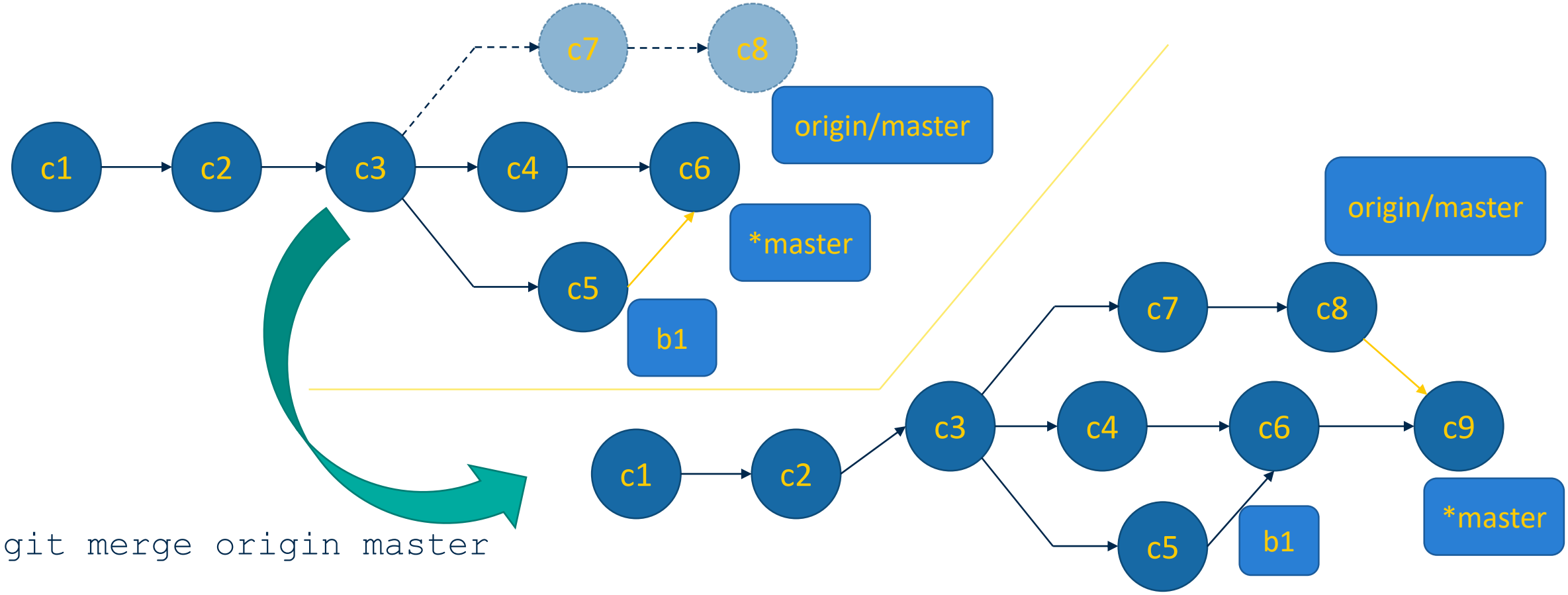
git concepts: merge



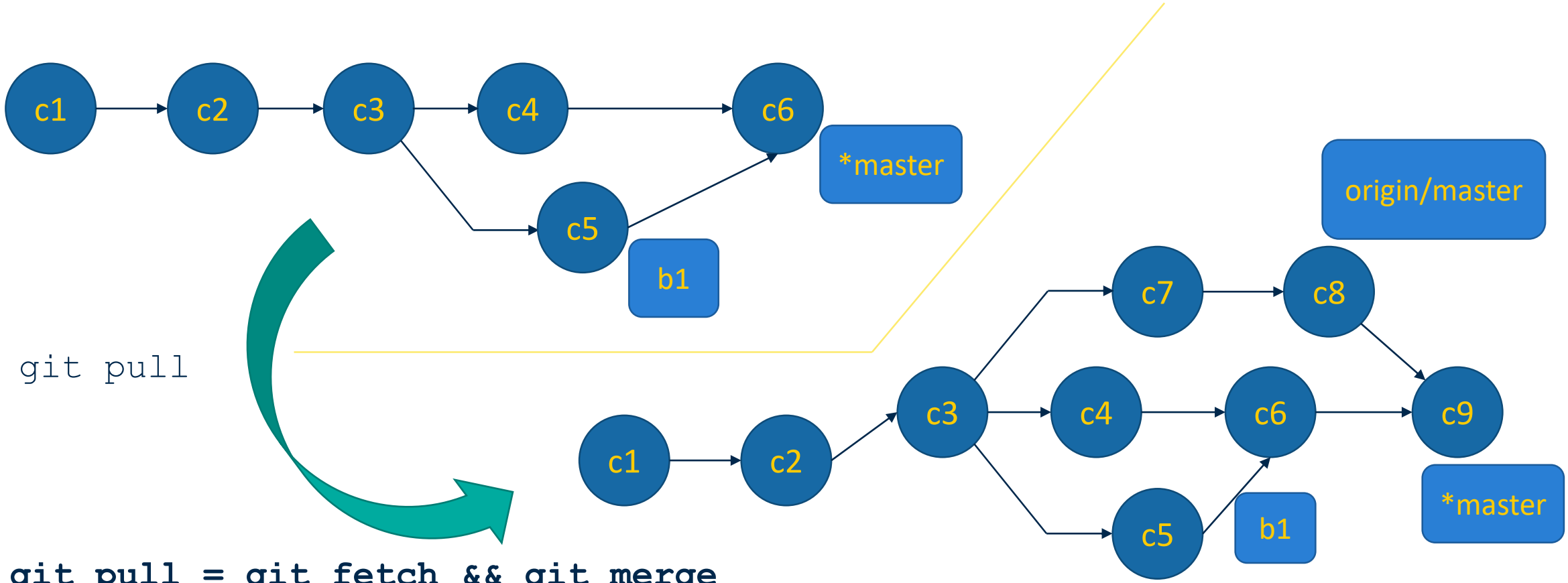
git concepts: fetch



git concepts: fetch (merge w/ remote)

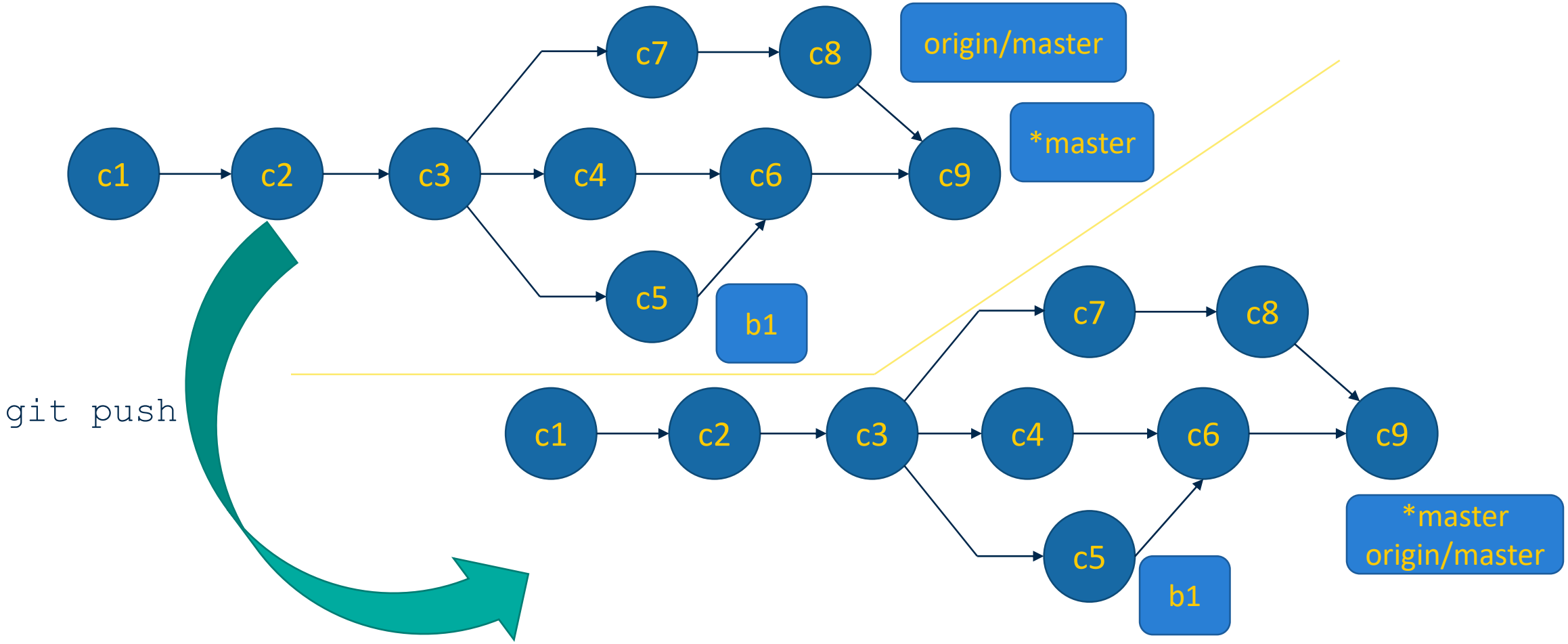


git concepts: pull



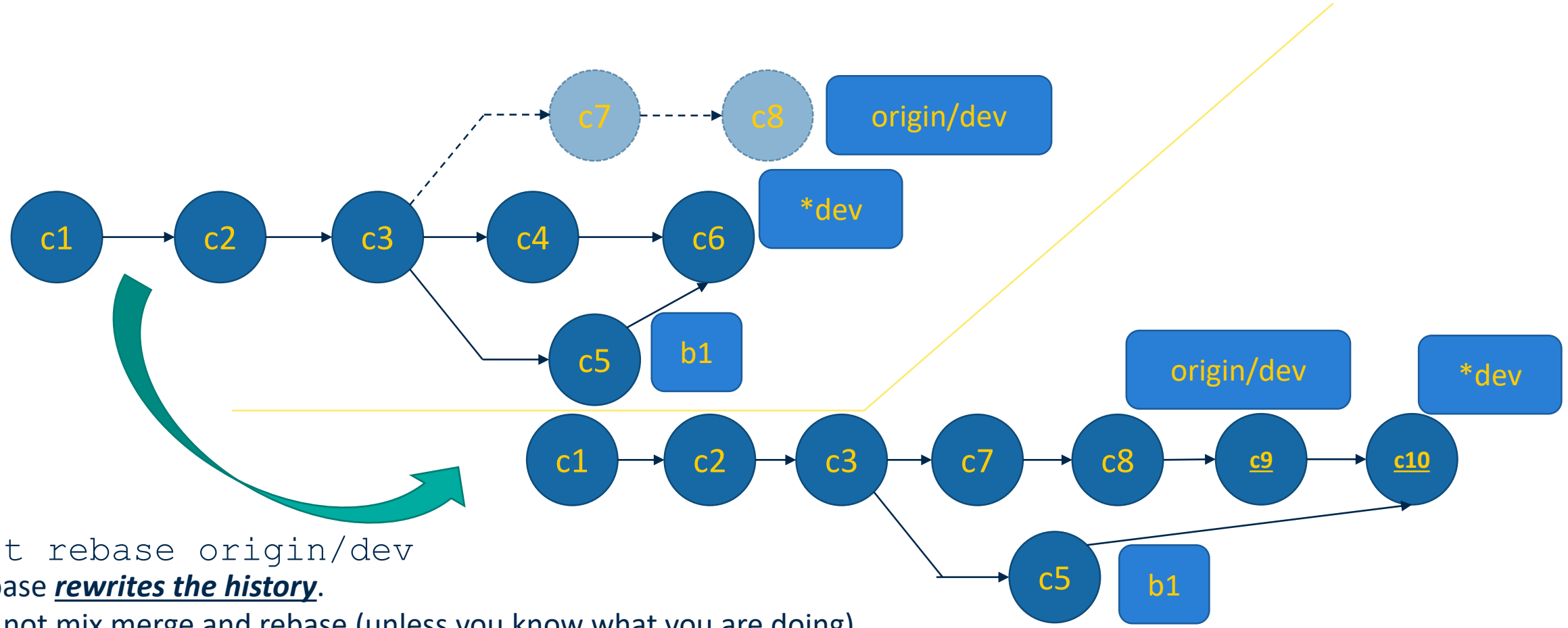
`git pull = git fetch && git merge`

git concepts: push



git concepts: rebase

(a dangerous, but sometimes useful alternative to merge)




```
git rebase origin/dev
```

rebase ***rewrites the history***.

Do not mix merge and rebase (unless you know what you are doing)