

CS179F: Projects in Operating System

Introduction

Emiliano De Cristofaro and Lian Gao

Team

- Instructor: Emiliano De Cristofaro (emilianodc@cs.ucr.edu)
 - I am a Professor in CSE working on [security, privacy, and cybersafety](#)
 - Office hours: TBA
- TA: Gao Lian
 - PhD student in cybersecurity
 - Office hours in lab on Wednesdays (more details later)

Projects

- 5 projects in xv6-riscv, one every 2 weeks, each 20% of the final grade
 - Unix Utilities: sleep, find, xargs
 - Memory Allocation
 - Copy-On-Write
 - File System: large files and symbolic links
 - mmap

Projects (with deadlines)

- 5 projects in xv6-riscv, one every 2 weeks, each 20% of the final grade
 - Unix Utilities: sleep, find, xargs Oct 18th, 1:59:59pm
 - Memory Allocation Nov 1st, 1:59:59pm
 - Copy-On-Write Nov 15th, 1:59:59pm
 - File System: large files and symbolic links Nov 29th, 1:59:59pm
 - mmap Dec 13th, 1:59:59pm

Project “Rules”

- Each project should be finished **individually**, unless the class size increases unexpectedly
 - Discussions are fine and encouraged
 - TA and I are there for help, try Piazza first before email
 - Other “ways” to get coding done? E.g., Github Copilot?
- Late policy
 - 20% if within 48 hours
 - No grading beyond 48 hours (exceptions granted with evidence)

Class Material

<https://github.com/emidec/cs179f-fall23>



Resources

- Operating Systems: Three Easy Pieces, Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau
- XV6: A Simple UNIX-like Teaching Operating System, Russ Cox, Frans Kaashoek, and Robert Morris
- Lions' Commentary on UNIX' 6th Edition, John Lions, Peer to Peer Communications. ISBN: 1-57398-013-7. 1st edition (June 14, 2000)
- A good guidance: <https://pdos.csail.mit.edu/6.828/2023/labs/guidance.html>

Communication

- Piazza (<https://piazza.com/ucr/fall2023/cs179f>) as the main communication channel
 - Announcements, slides, projects, polls, etc.
 - Discussion and Q&A
- Canvas (<https://elearn.ucr.edu/courses/110956>)
 - For assignments and grades



Class Schedule

- Lectures: Tuesdays 3:30-4:20pm, Watkins 1101 (Oct 3 - Dec 5)
- Labs: Wednesdays 6:00-8:50pm, Sproul Hall 2340 (Oct 4 - Dec 6)
- **We don't need both sessions every week. Proposed schedule:**
 - Tuesday in-person lectures: every 2 weeks (**mandatory** attendance)
 - Wednesday in-lab **Lian** office hours: every week (optional but strongly recommended)
 - Wednesday in-lab **Emiliano** office hours: every 2 weeks (optional)
- + Emiliano office office hours, Zoom (on appointment, details TBD)

Week 1

- Tue Oct 3: Lecture
- Wed Oct 4: EDC + Lian lab

Week 2

- Tue Oct 10: Lecture
- Wed Oct 11: Lian lab

Week 3

- Wed Oct 18: EDC+ Lian lab

Week 4

- Tue Oct 24: Lecture
- Wed Oct 25: Lian lab

Week 5

- Wed Nov 1: EDC+ Lian lab

Week 6

- Tue Nov 7: Lecture
- Wed Nov 8: Lian lab

Week 7

- Wed Nov 15: EDC+ Lian lab

Week 8

- Tue Nov 21: Lecture
- Wed Nov 22: Lian lab

Week 9

- Wed Nov 28: EDC+ Lian lab

Week 10

- Tue Dec 5: Lecture
- Wed Dec 6: Lian lab

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Lab 1 due:
Oct 18th, 1:59pm

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- Wed Nov 1: EDC+ Lian lab

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Nov 1st, 1:59pm

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- Tue Nov 7: Lecture
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- Wed Nov 15: EDC+ Lian lab

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- Tue Nov 21: Lecture
- Wed Nov 22: Lian lab

Lab 4 due:
Nov 28th, 1:59pm

Week 9

- Wed Nov 28: EDC+ Lian lab

Week 10

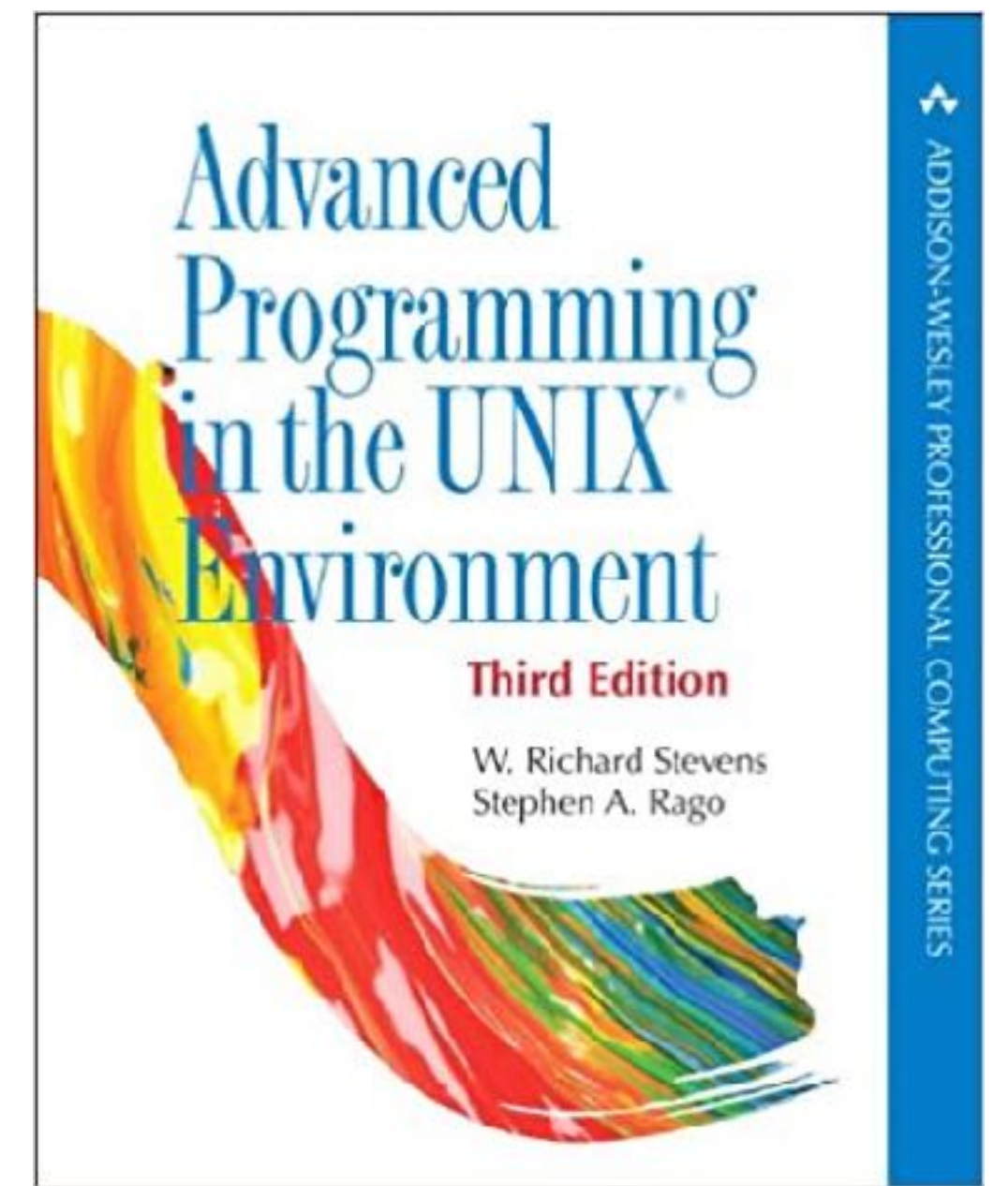
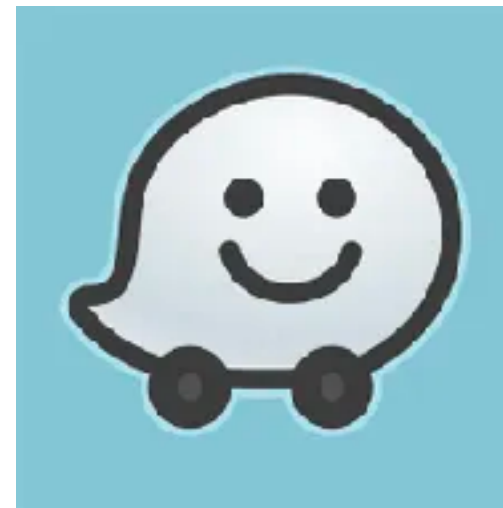
- Tue Dec 5: Lecture
- Wed Dec 6: Lian lab

Lab 5 due:
Dec 13th, 1:59pm

Objectives

Why taking this class?

- Get familiar with system programming (lab 1)
 - Purpose of OS: help app developers achieve their goals
 - System programming: leverage what the OS provides (via syscalls) to implement ideas
 - For example: `sleep`, `ls`, `find`, `grep`, `xargs`
 - For example:



Objectives

Why taking this class?

- Have a better understanding of how OS works, why?
 - Trouble shooting
 - Why I can only open `NFILE` files?
 - Why I can't have files larger than 268 blocks?
 - Performance: I have a bottleneck at reading files
 - Capabilities: what if the kernel doesn't have what I want?

Objectives

Why taking this class?

- Have better understanding about OS concepts
 - Copy-on-write
 - Lazy allocation
 - Memory mapped files
 - inode

Objectives

Why taking this class?

- Further improve your problem solving skills
 1. Understand what is the task
 - What is the **input** and what is the **output**?
 2. Sketch your solution
 - What information is required? How to process the info?
 3. Prepare some test cases (from simple to complex/corner cases)
 4. Implement your solution and test it

Objectives

Why taking this class?

- Further improve your debugging skills
 - `why user tests fail?!`

Additional Objectives?

- Have a taste of AI assistants
- At the beginning of the quarter
 - Github Copilot, ChatGPT
- By the end of the quarter
 - GPT-4, Microsoft 365 Copilot, LLaMA (Meta), PaLM (Google)

Who Should be Worried?

Extra Credits?

- Re-implementation of attacks or defenses against/for systems/OS security
 - Papers published in top-tier security conferences

Environment — xv6

- We will use the XV6 operating system as a base for our projects
 - A re-implementation of Unix Version 6 for a modern RISC-V multiprocessor using ANSI C
- Familiarize yourself with XV6 on how it is organized and implemented:
 - Take a look at the online version of the Lions commentary
 - Look at the source code, etc.

Tools

- **xv6-riscv** (see previous slide/class GitHub)
- **qemu** (open source machine emulator and virtualizer)
- **labs code** (on class repo)

See README.md on the class repo (<https://github.com/emidec/cs179f-fall23>) for more info on how to set everything up

Note: currently having trouble with Mac (use Linux VM) and new versions of qemu (use v4 or v5, not v8)

Lab 1

- Implement the UNIX program **sleep** for xv6
- Write a simple version of the UNIX **find** program: find all the files in a directory tree with a specific name
- Write a simple version of the UNIX **xargs** program: read lines from the standard input and run a command for each line, supplying the line as arguments to the command

See class git repo / <https://github.com/emidec/cs179f-fall23/blob/xv6-riscv-fall23/doc/lab1.md>

Lab 1 — Util

- Quick reference:
 - `$ make qemu // compile and run xv6`
 - `$ make grade // test your solution with the grading program`
 - `$./grade-lab-util sleep`
 - `$ Make GRADEFLAGS=sleep grade`
 - To quit qemu type: `ctrl+a x`
- To compile your program:
 - Add your program under `/xv6-riscv/user` named as `<prog>.c`
 - Modify `UPROGS` in Makefile accordingly

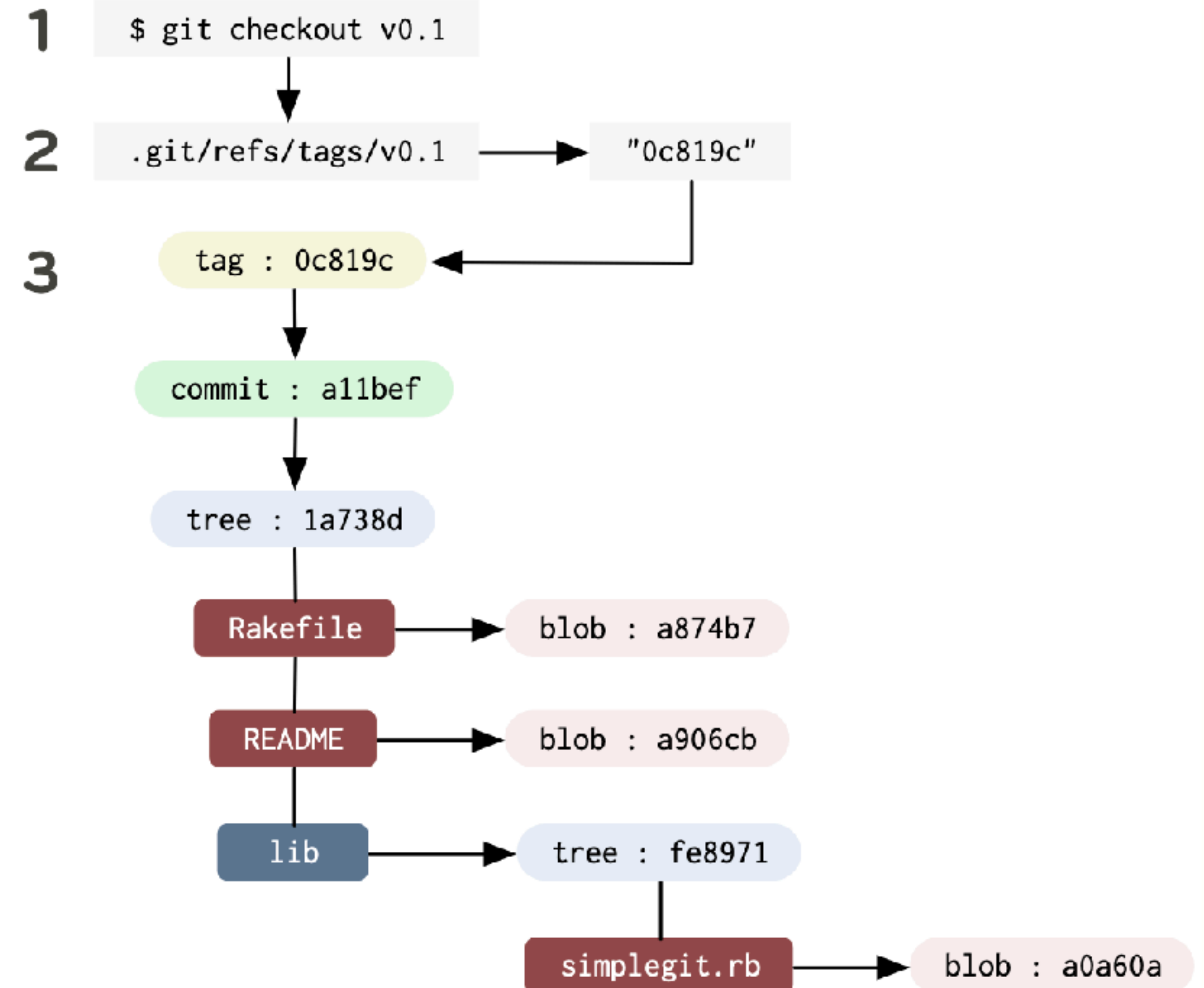
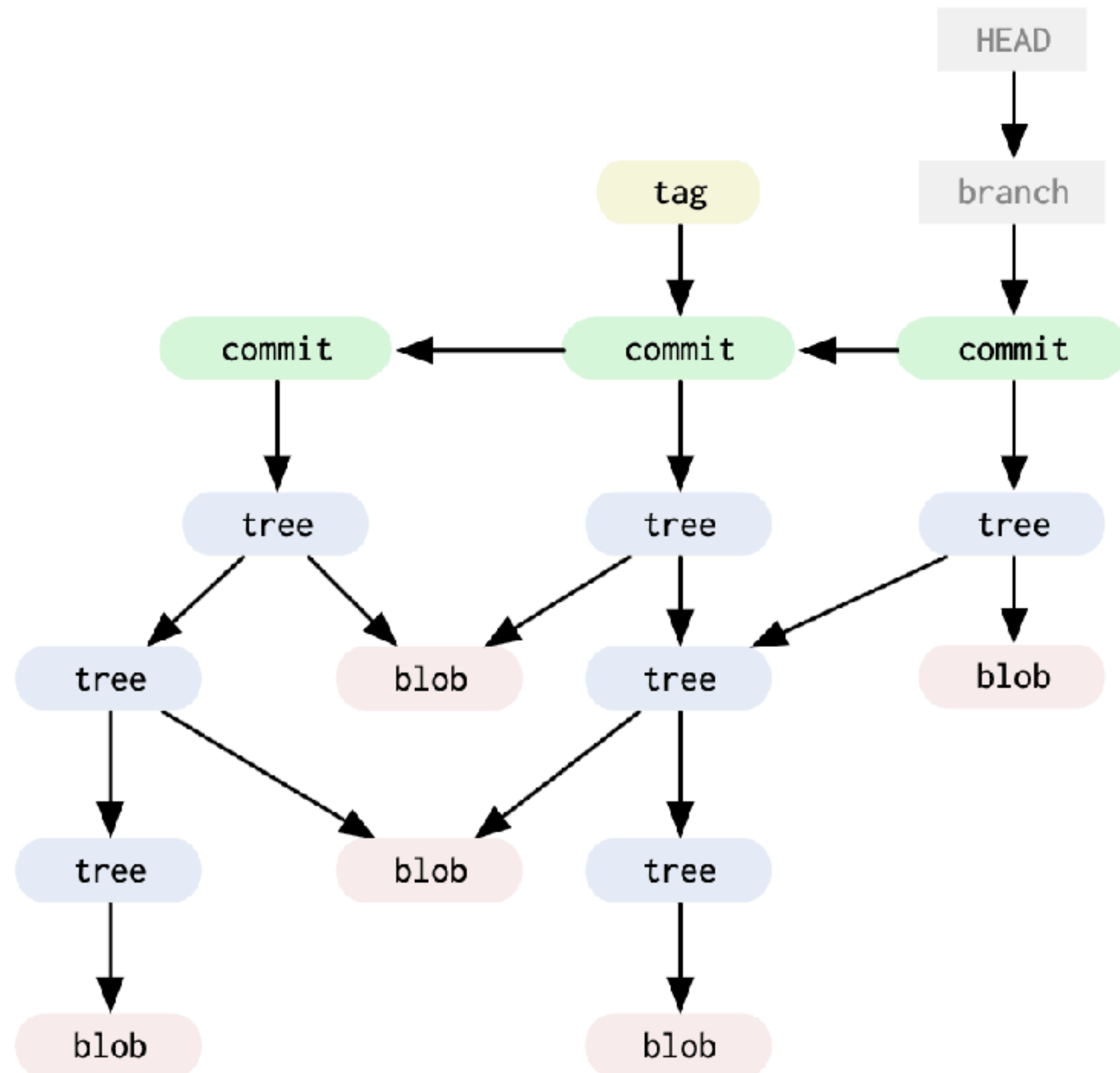
GIT

A quick introduction

- A version control system (and a file system)
 - Data is stored as `blobs` (files) and `trees` (directories)
 - `commit`: a commit is a **reference** (with a message/comment) to a `tree`, which represents the state of the project (fs), the ID of a `commit` is a SHA-1 hash
 - `refs`: named **references** to `commits/refs`, such as `HEAD`, `HEAD^1`, `TAGS`, `branches`
 - `remote refs`: **references** to a remote project (fs)

GIT

Structure and traversal



GIT

Why we like it?

- Everything is self-contained, no central storage (subversion, CVS), no background services/daemons
 - Want to backup? Just copy the project directory
 - Access to remote branches? SSH is enough (e.g., `sledge:xv6`)
 - Fully distributed, excellent support for parallel development
- Fast, simple, support anything
 - You can use git to version control everything

GIT

Basic operations

- `clone`: copy the whole thing (directory)
- `checkout`: go to a commit
- `diff`: show what has changed
- `add`: what changes to be included in a commit
- `commit`: snapshot the state and add a message
- `log`: examine the history
- `stash`: temporarily save the current changes

GIT

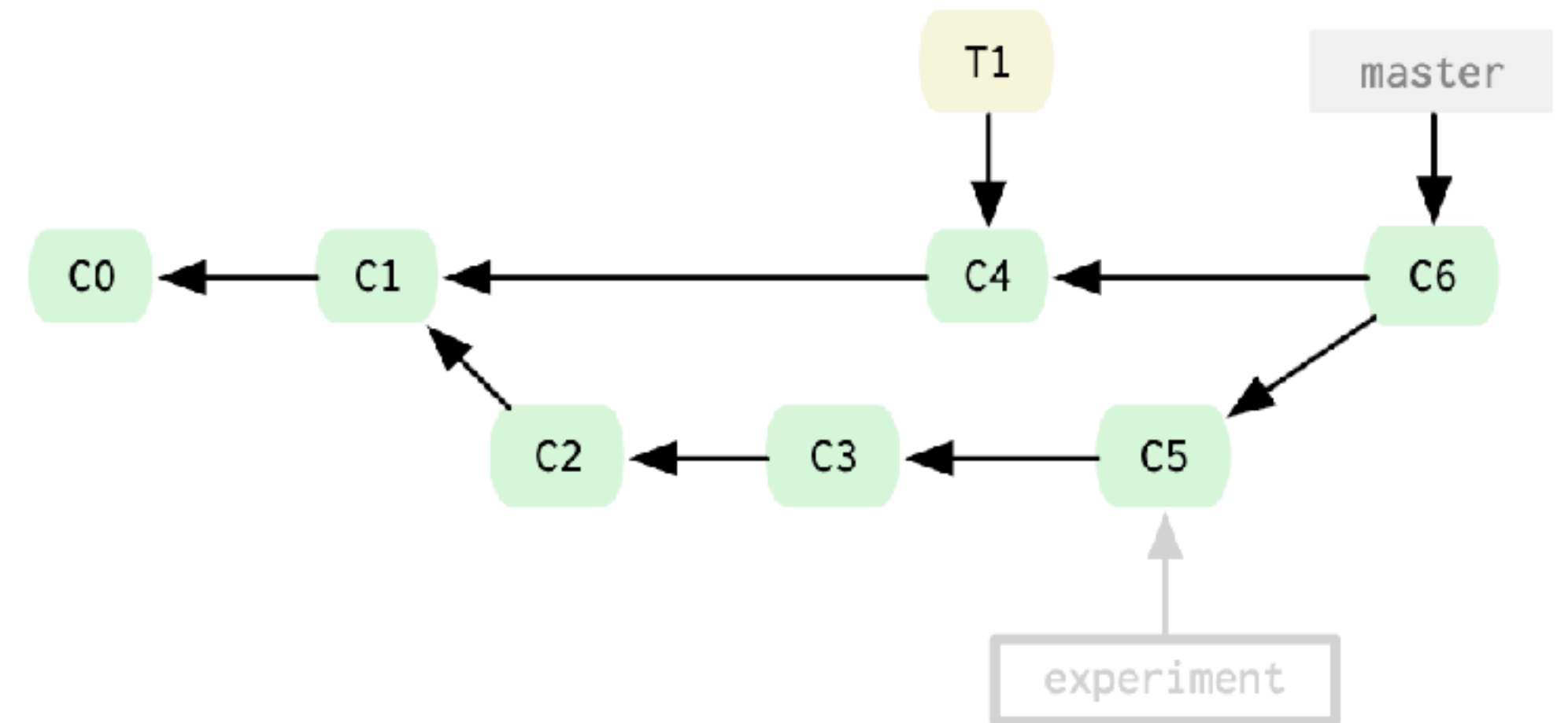
A bit more advanced operations

- branching: how to create a new branch?
 - `git checkout -b bname`: creates a new ref with name bname, unnamed commits is hard to go back
- revert changes: if mistakenly changed something, how to restore?
 - `git checkout/restore`
- revert changes: what if the unwanted changes have been committed?
 - `git checkout`: you can always go back to any snapshot (e.g., `HEAD^`, the previous commit)

GIT

A bit more advanced operations

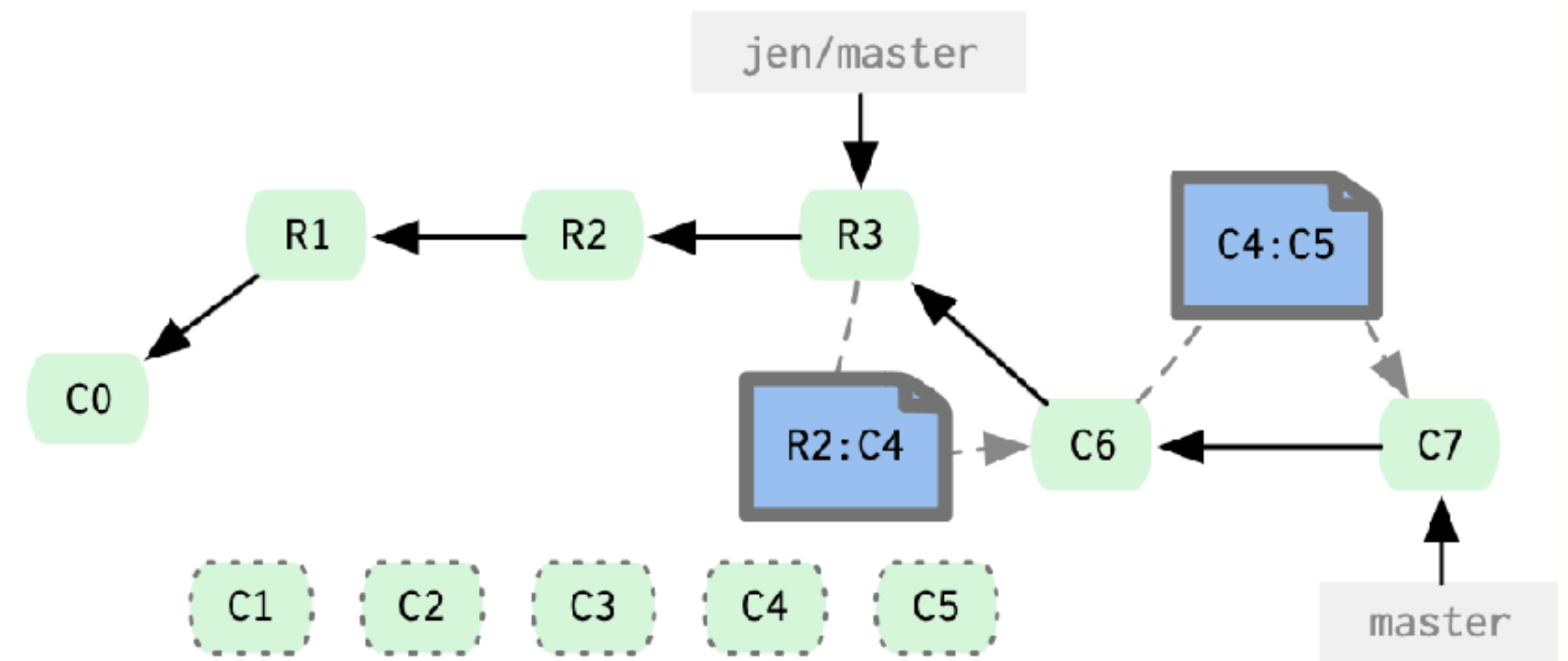
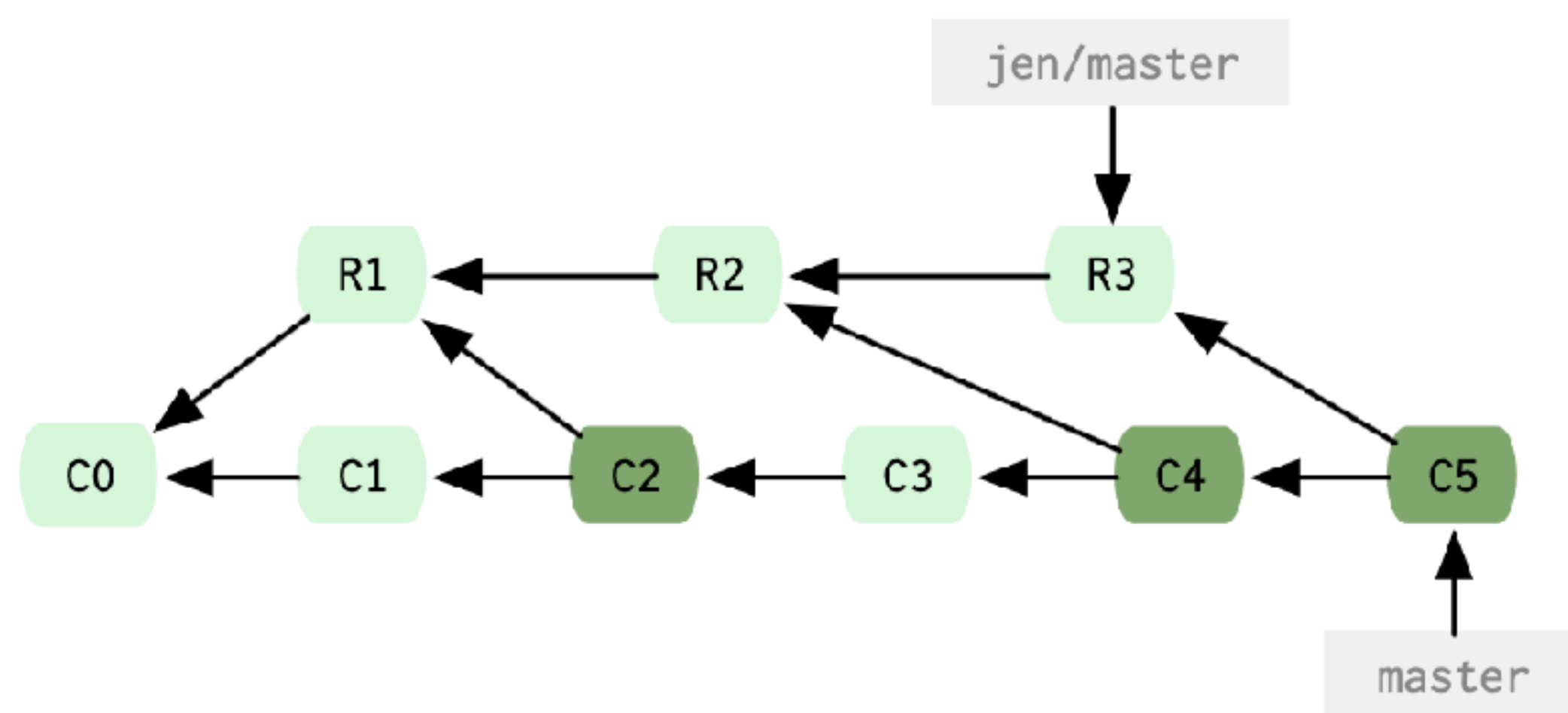
- merge: combine two snapshots
 - `git merge ref: ref` could be another (remote) branch, or just a commit
 - nothing changed? cool, it's just a fast forward (moving the HEAD ref to point to the same commit)
 - CONFLICTS? git will try to automatically resolve as many conflicts as possible, the remaining ones have to be manually resolved



GIT

A bit more advanced operations

- `rebase`: combine changes, simplify the version history



GIT

Access to remote branches

- `fetch`: retrieve the new items (blobs, trees, refs, etc) from remote
- `pull`: `fetch` + `merge`
- `push`: store new items to remote

GITHUB

- A (mostly) free service to remotely store your git-managed projects
- And other features for project management
 - ISSUES: tracking problems and discuss solutions
 - WIKI: documentation
 - PULL REQUESTS: better managed merging
 - PROJECTS: planning and tracking
 - ACTIONS: automations, CI/CD

Questions?

