Principles of Software Construction: Objects, Design, and Concurrency

Managing change

Charlie Garrod **Bogdan Vasilescu**

School of Computer Science

institute for SOFTWARE RESEARCH

Intro to Java

Git, CI

UML

GUIs

Static Analysis

Performance

Lambdas and streams

More Git

DevOps

More design patterns

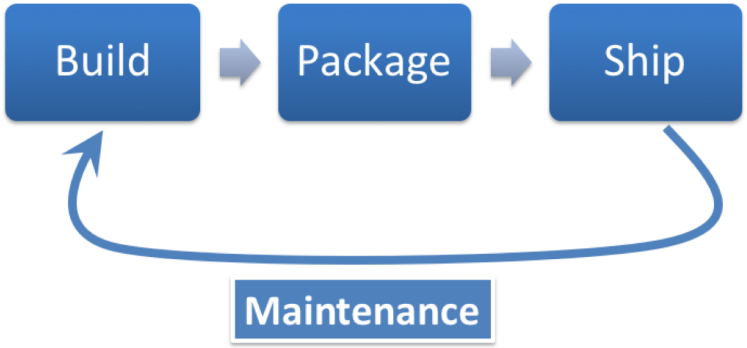
Part 1: Design at a Class Level	Part 2: Designing (Sub)systems	Part 3: Designing Concurrent Systems
Design for Change: Information Hiding, Contracts, Unit Testing, Design Patterns Design for Reuse: Inheritance, Delegation, Immutability, LSP, Design Patterns	Understanding the Problem Responsibility Assignment, Design Patterns, GUI vs Core, Design Case Studies Testing Subsystems Design for Reuse at Scale: Frameworks and APIs	Concurrency Primitives, Synchronization Designing Abstractions for Concurrency

Administrivia

- Homework 6 checkpoint deadline (Monday, April 30th)
- Homework 6 due Wednesday, May 2nd
- Final exam Monday May 7th 5:30-8:30 PH 100
- Review session Saturday May 5th

Key concepts from Carnival

Scenario



A customer wants a bug fix to software version 8.2.1, which was released 2 years ago.

How to make sure we can fix, build, and release?

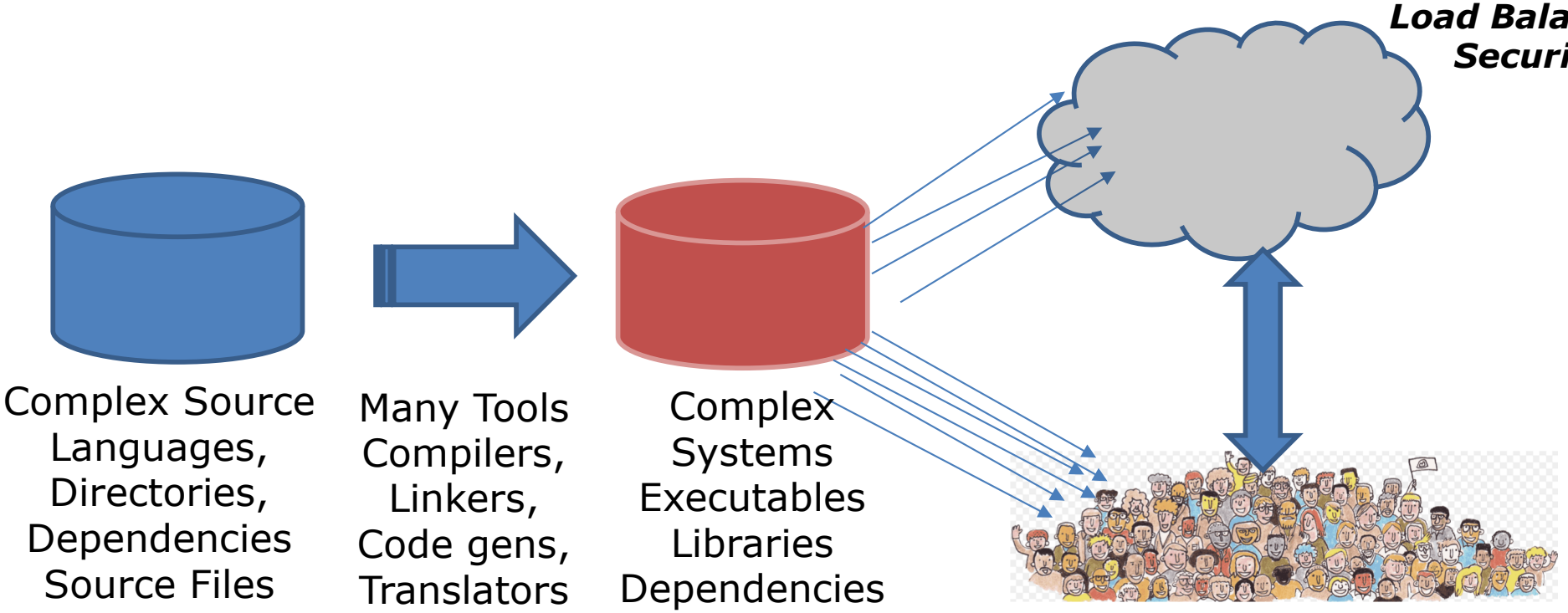
Configuration Management (CM)

Pressman:

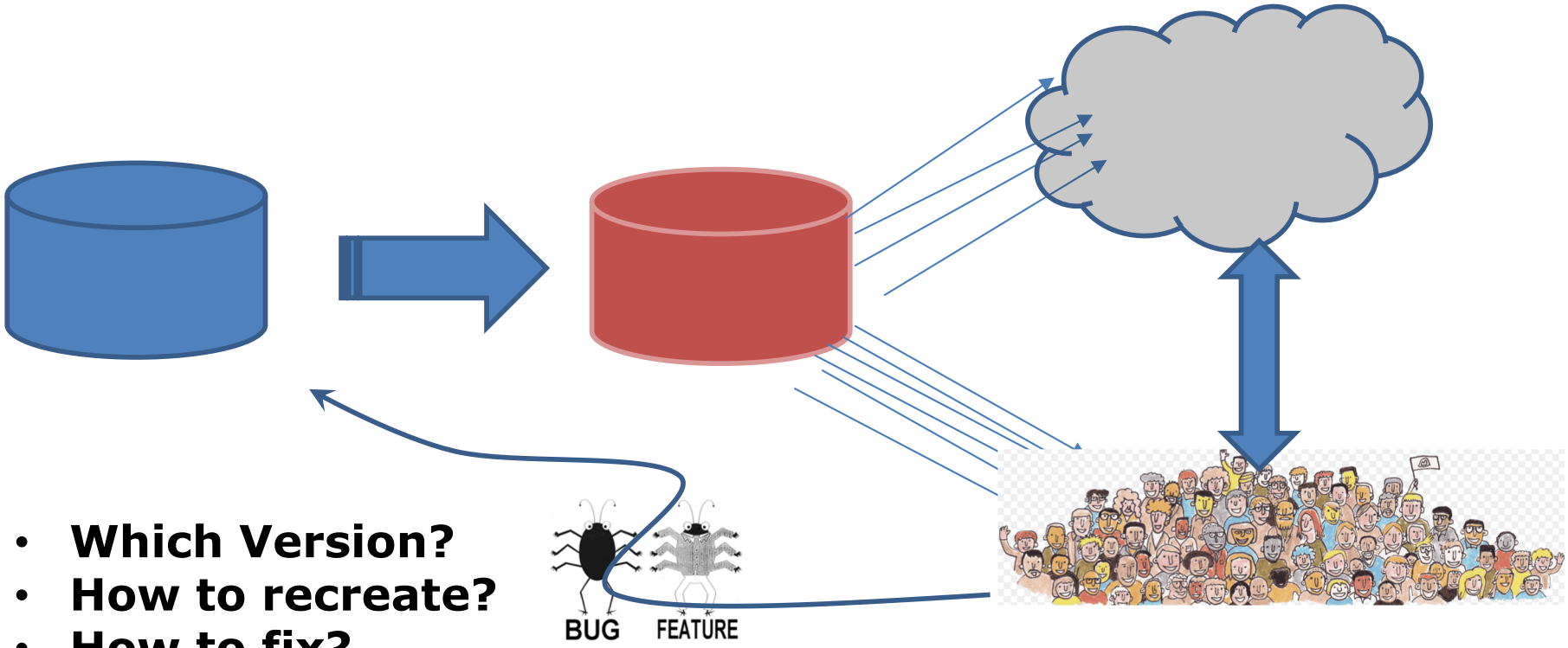
"is a set of tracking and control activities that are initiated when a software engineering projects begins and terminates when software is taken out of operation"

Configuration management originates from the 50s, when spacecraft failures resulted from undocumented changes.

The Modern World

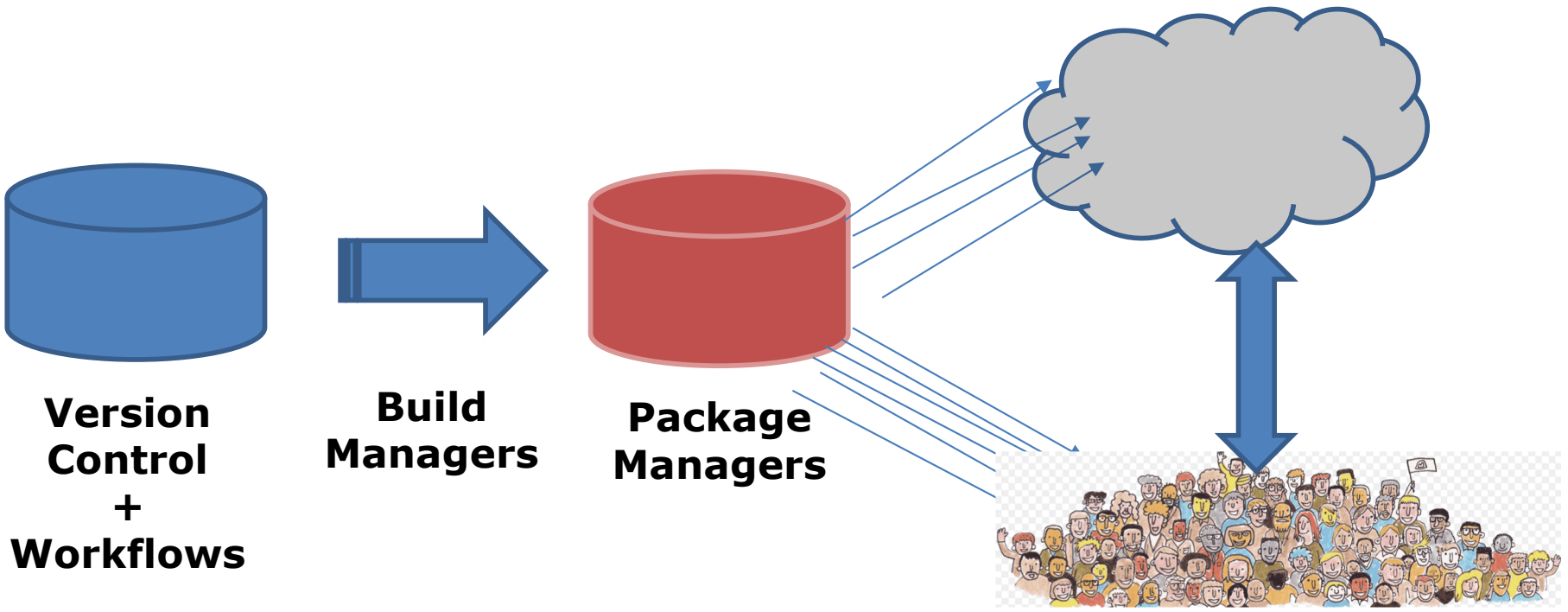


The Modern World



- **Which Version?**
- **How to recreate?**
- **How to fix?**
- **Where to apply the fix?**
- **How/when to Redistribute?**

Components of Modern CM



Configuration management as safety net

- Doing software development without CM is “working without a safety net”

- Configuration management refers to both a process and a technology
  - The process encourages developers to work in such a way that changes to code are tracked
    - changes become “first class objects” that can be named, tracked, discussed and manipulated
  - The technology is any system that provides features to enable this process

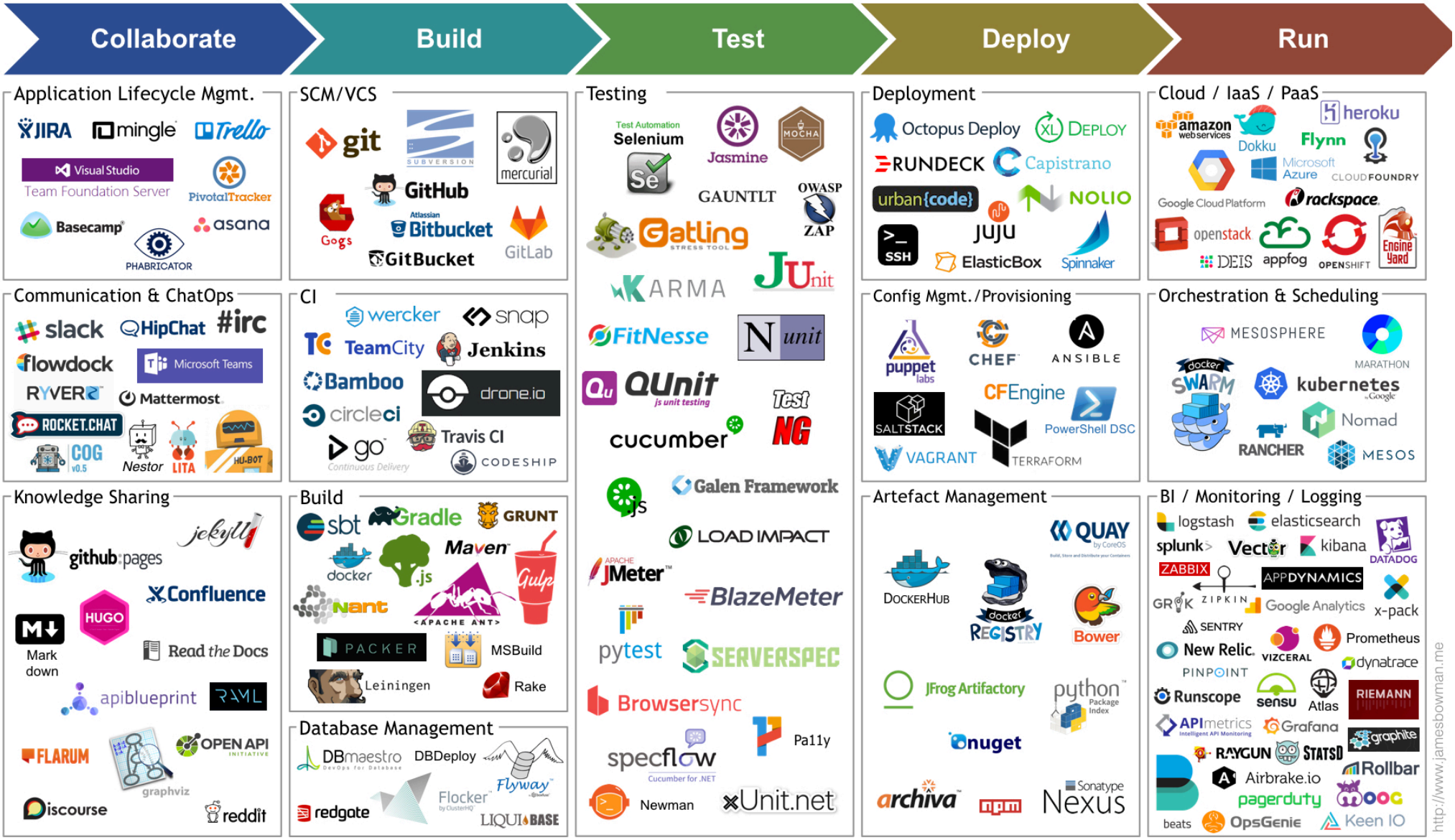
Activity

In pairs, discuss other reasons why we may want configuration management

Some reasons

- “Works for me”; difficulty onboarding new devs, installing dependencies
- Audits: Discovery request on changes made to system (e.g. no tracking in breathalyzer lawsuit)
- Product lines (Home, Business, Professional); different customer types.
- Markets: Asia, Europe, America (Language + feature variance)
- Platforms: Windows, Mac OS, Android, iOS

CM is a key part of DevOps (more later)



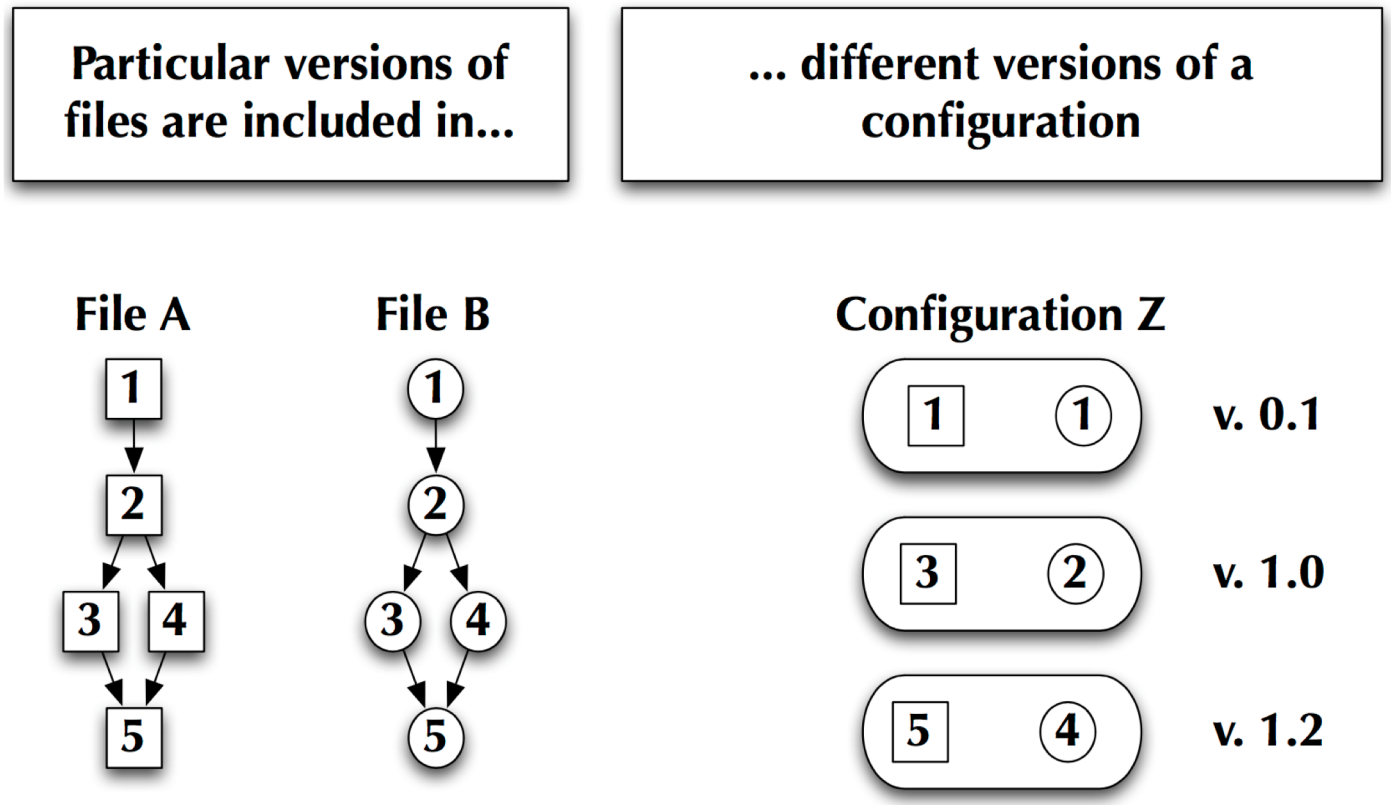
Components of Modern CM

Version Control: Branches/Forks/Workflows
Task and Build managers
Build machines, virtual environments (dev stacks)
Package managers
Containers, VMs, in the Cloud
Deployment – Infrastructure as Code.
Data migration

Other issues: orchestration, inventory, compliance

Config. management vs version control

- "version control" is "versioning" applied to a single file while "configuration management" is "versioning" applied to collections of files



VERSION CONTROL WITH GIT

A. GOAL: COLLABORATION ON FILES

Collaborating on Files

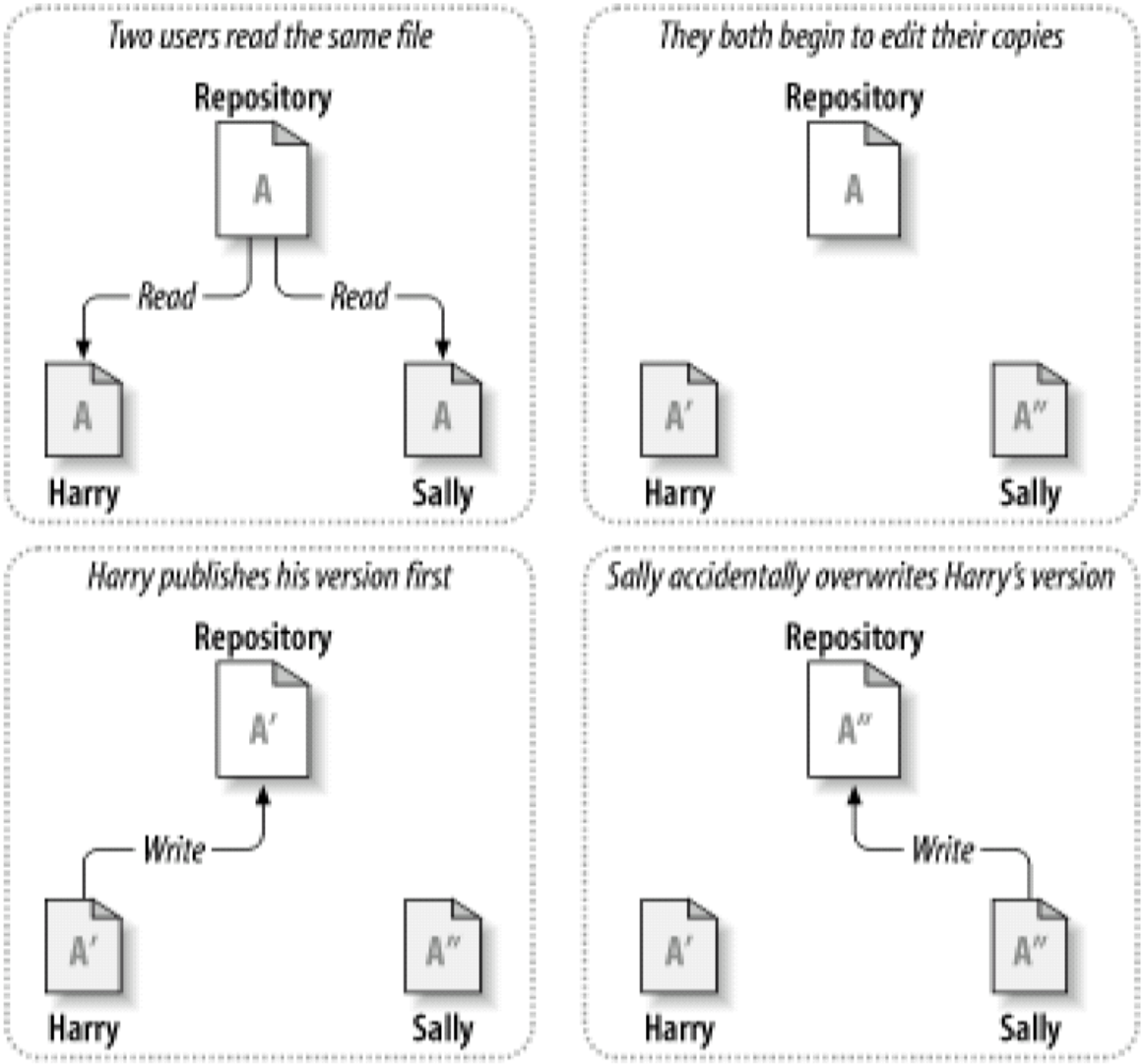
- How to exchange files
  - Send changes by email
  - Manual synchronization at project meeting
  - All files on shared network directory

- Permission models
  - Each file has an owner; only person allowed to change it
  - Everybody may change all files (collective ownership)

Concurrent Modifications

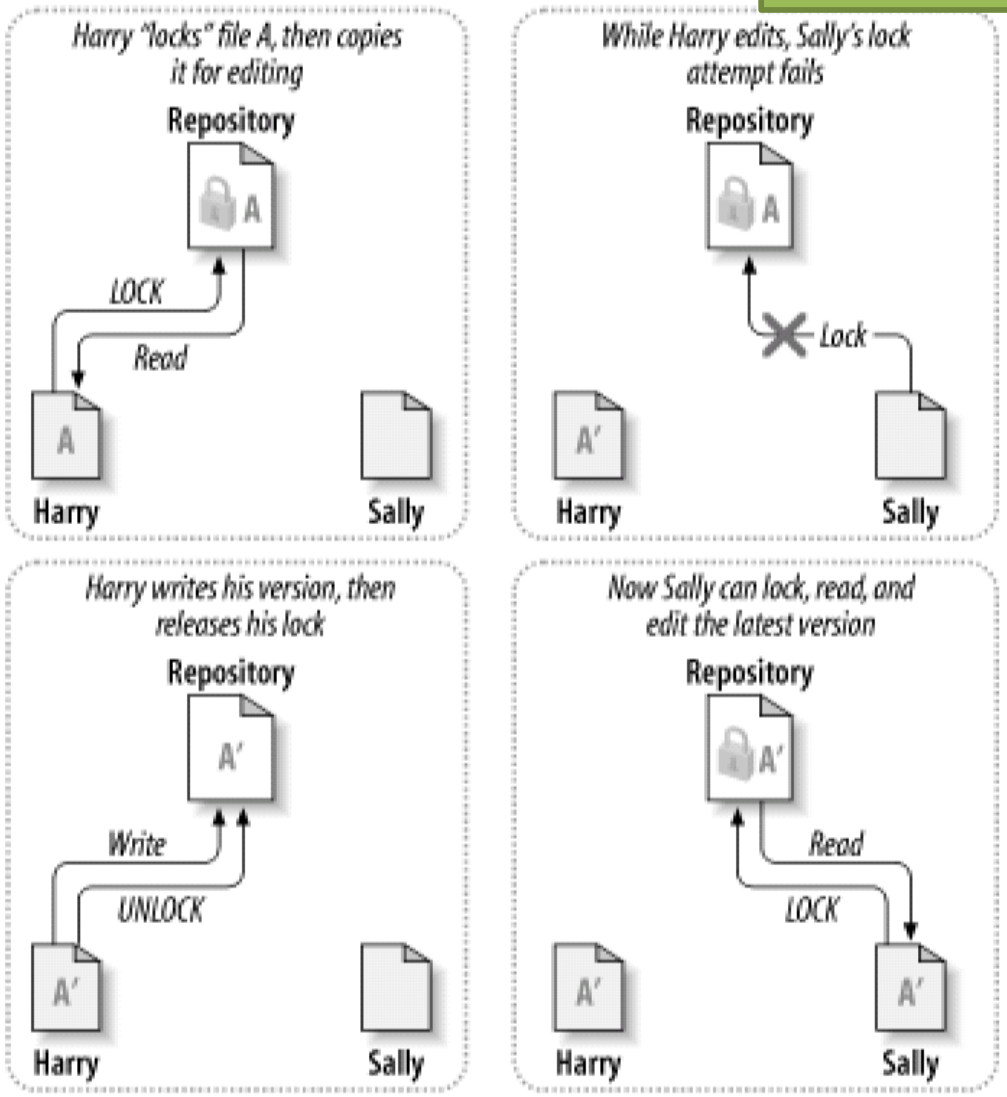
- Allowing concurrent modifications is challenging
- Conflicts (accidental overwriting) may occur
- Common strategies
  - Locking to change
  - Detecting conflicts (optimistic model)

Change Conflicts

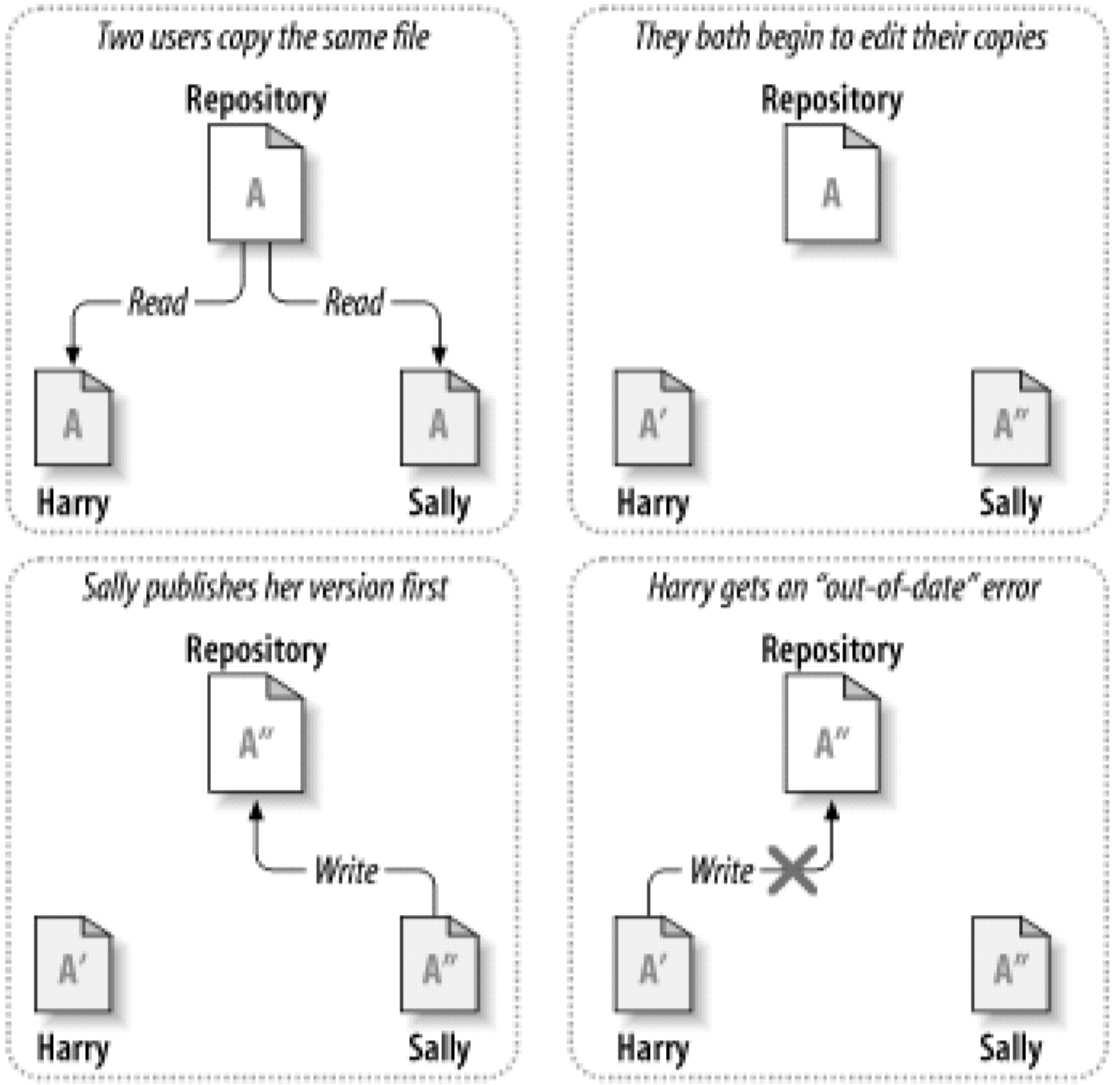


Locking Files

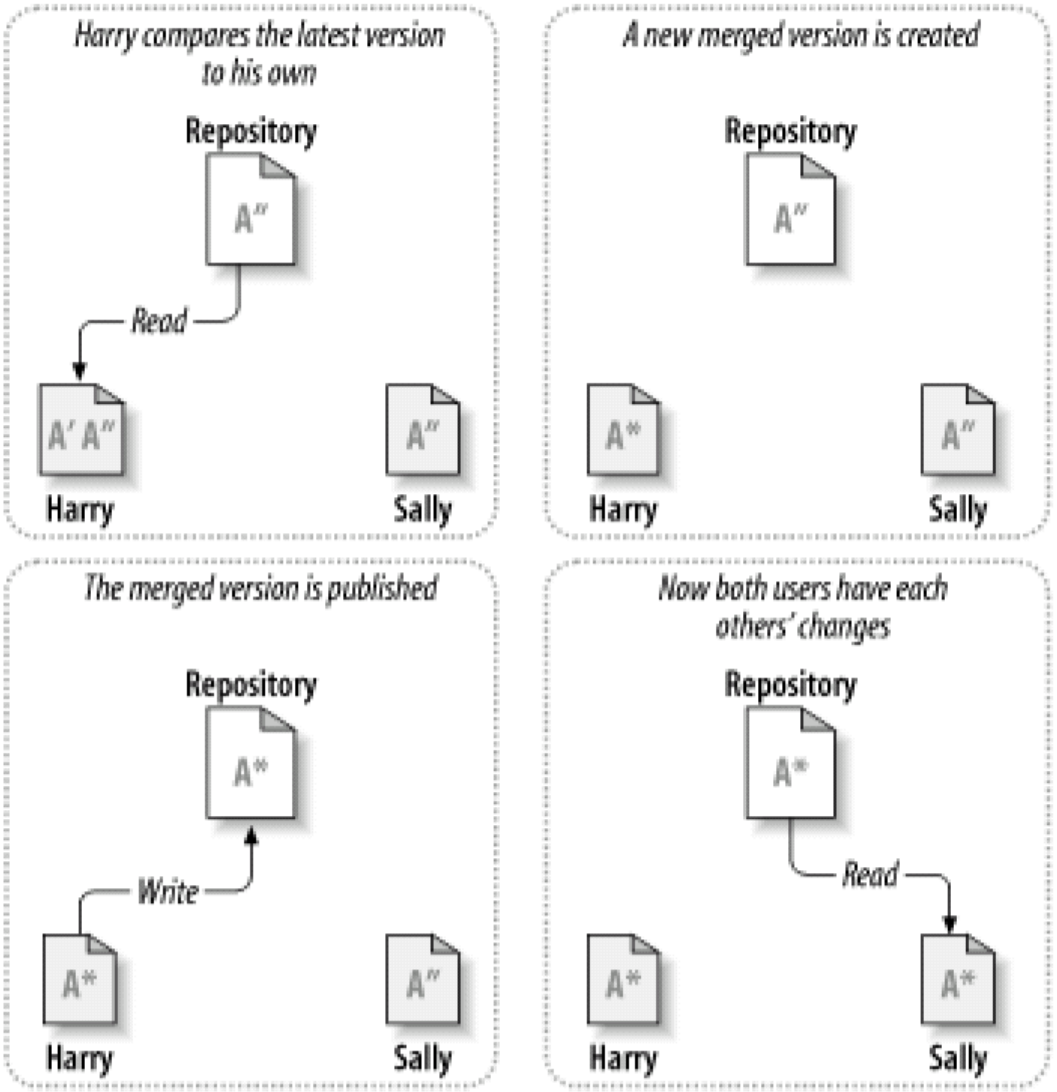
Practical problems of locking model?



Merging (1/2)


Two users copy the same file
Repository
A
Read
Read
A
A
Harry
Sally
They both begin to edit their copies
Repository
A
A′
A″
Harry
Sally
Sally publishes her version first
Repository
A″
Write
A′
A″
Harry
Sally
Harry gets an "out-of-date" error
Repository
A″
Write
A′
A″
Harry
Sally

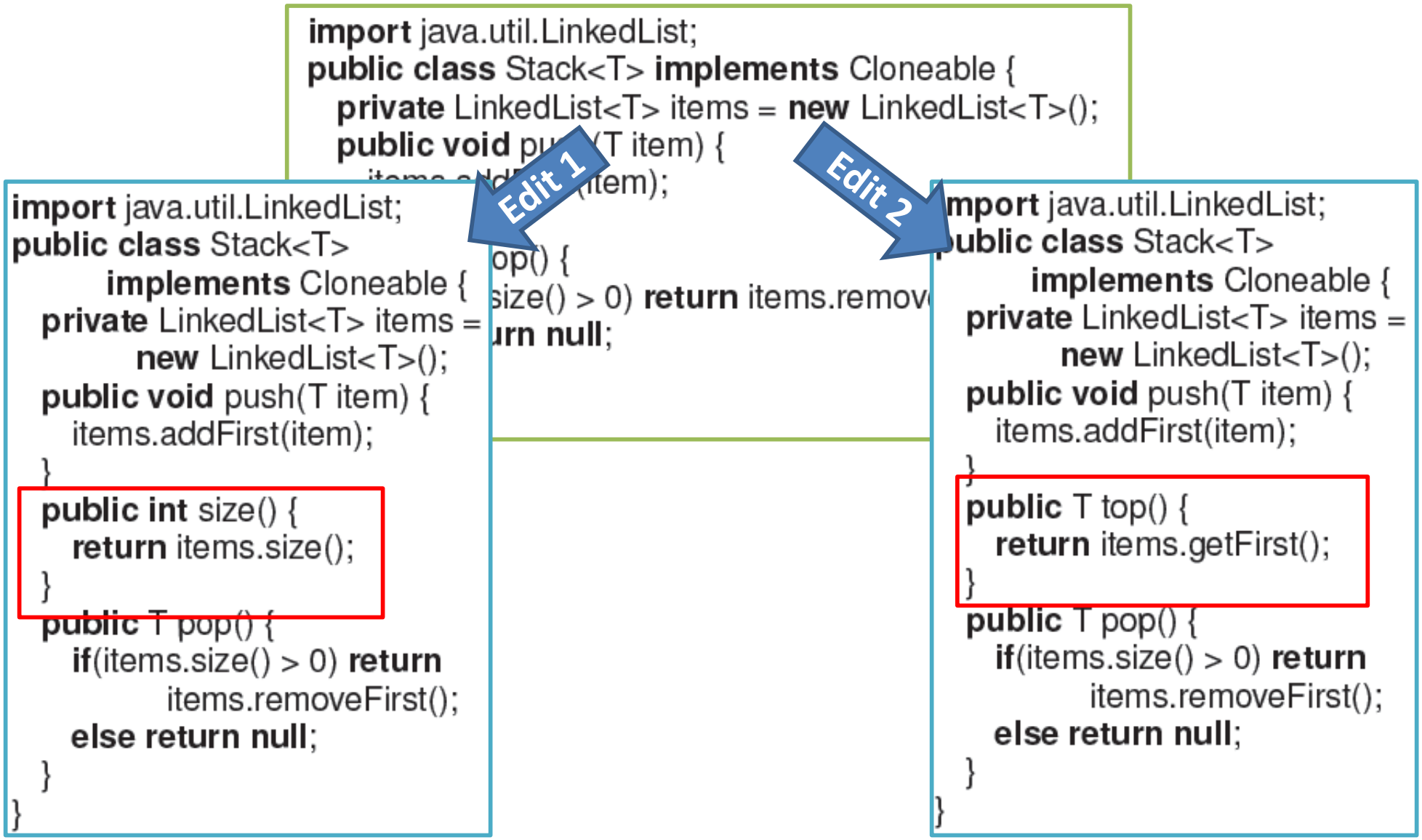
Merging (2/2)


Harry compares the latest version to his own
Repository
A″
Read
A′ A″
A″
Harry
Sally
A new merged version is created
Repository
A″
A*
A″
Harry
Sally
The merged version is published
Repository
A*
Write
A*
A″
Harry
Sally
Now both users have each others' changes
Repository
A*
Read
A*
A*
Harry
Sally

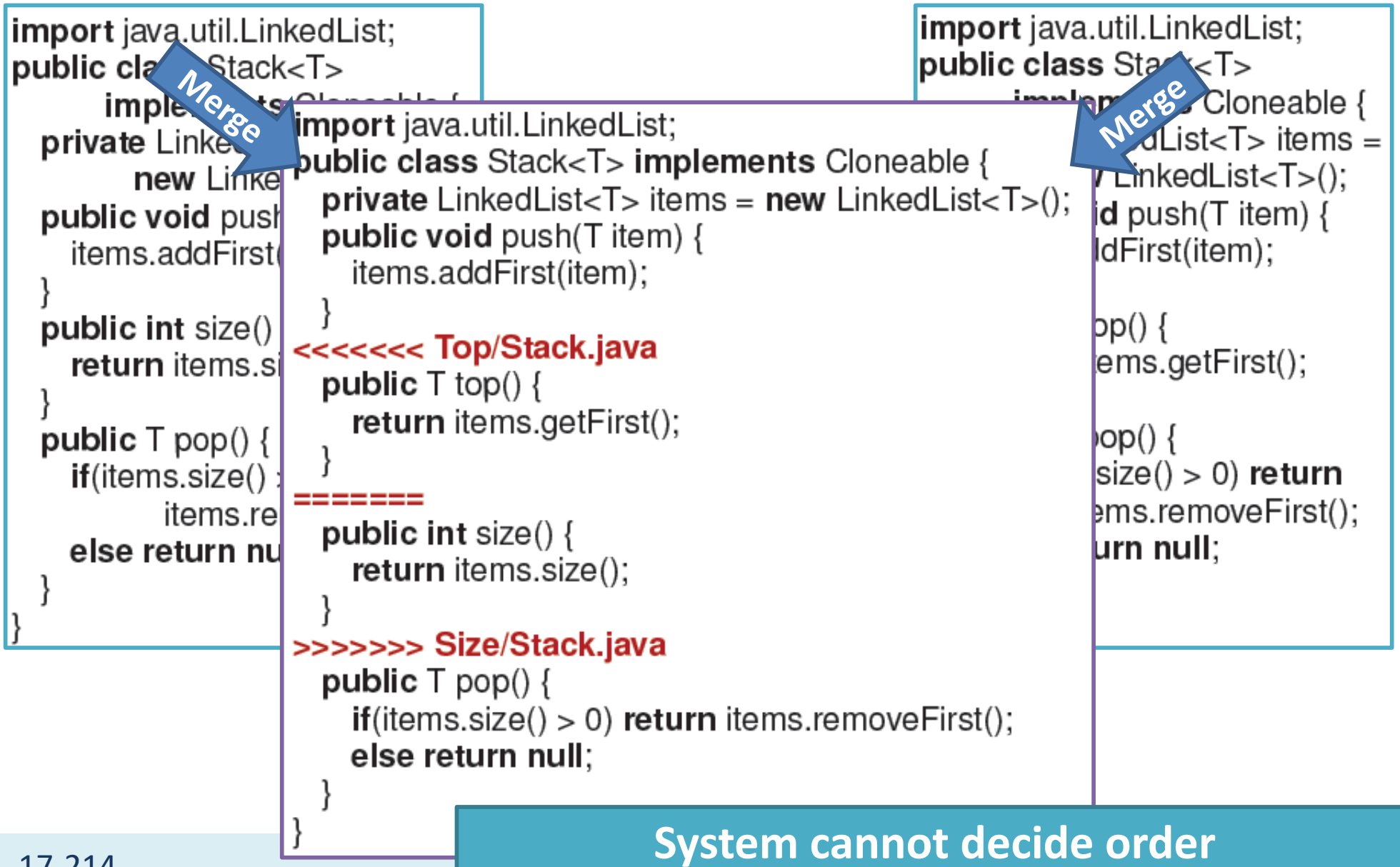
Example

```
import java.util.LinkedList;
public class Stack<T> implements Cloneable {
   private LinkedList<T> items = new LinkedList<T>();
   public void push(T item) {
      items.addFirst(item);
   }
   public T pop() {
      if(items.size() > 0) return items.removeFirst();
      else return null;
   }
}
```

Example


import java.util.LinkedList;
public class Stack<T> implements Cloneable {
private LinkedList<T> items = new LinkedList<T>();
public void pu (T item) {
(item);
op() {
size() > 0) return items.remov
urn null;
Edit 1
Edit 2
import java.util.LinkedList;
public class Stack<T>
implements Cloneable {
private LinkedList<T> items =
new LinkedList<T>();
public void push(T item) {
items.addFirst(item);
}
public int size() {
return items.size();
}
public T pop() {
if(items.size() > 0) return
items.removeFirst();
else return null;
}
}
import java.util.LinkedList;
public class Stack<T>
implements Cloneable {
private LinkedList<T> items =
new LinkedList<T>();
public void push(T item) {
items.addFirst(item);
}
public T top() {
return items.getFirst();
}
public T pop() {
if(items.size() > 0) return
items.removeFirst();
else return null;
}
}

Example


Merge
Merge
<<<<<<< Top/Stack.java
=======
>>>>>>> Size/Stack.java
System cannot decide order

3-way merge

- File changed in two ways
  - Overlapping changes -> conflicts
  - Merge combines non-conflicting changes from both
- Merging not always automatic
  - diff tool to show changes
  - Manual resolution of conflicts during merge (potentially requires additional communication)
- Automatic merge potentially dangerous
  -> syntactic notion of conflicts
- Merging of binary files difficult
- In practice: most merges are conflict free

B. GOAL: RELEASE MANAGEMENT

Challenge:

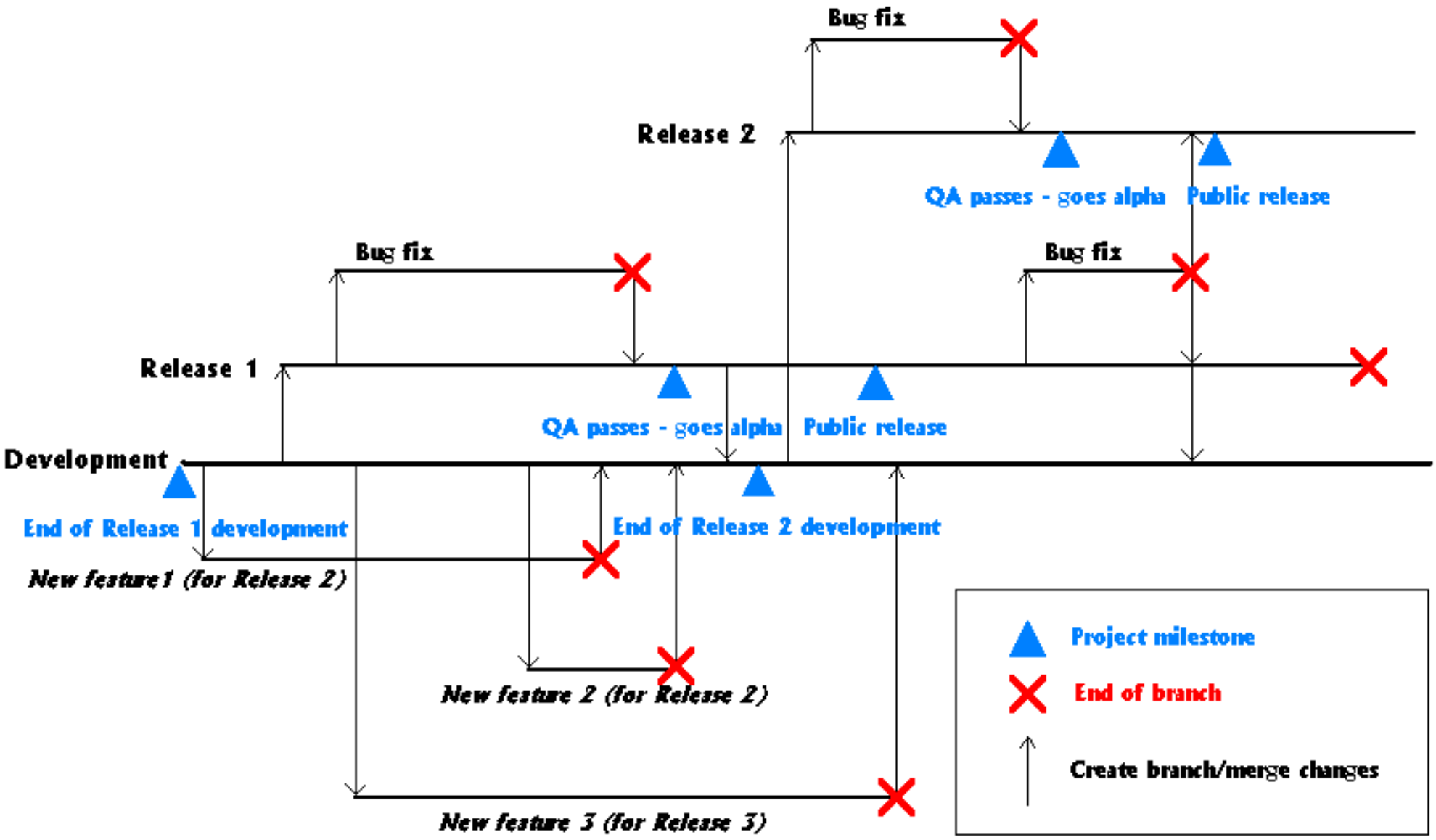
- Refer to concrete consistent versions of the project (code and all dependencies and infrastructure)

- Why?
  - Parallel development of independent features
  - Bug fixes for old releases; patches
  - Variants for different customers
  - Traceability and accountability of changes (provenance)

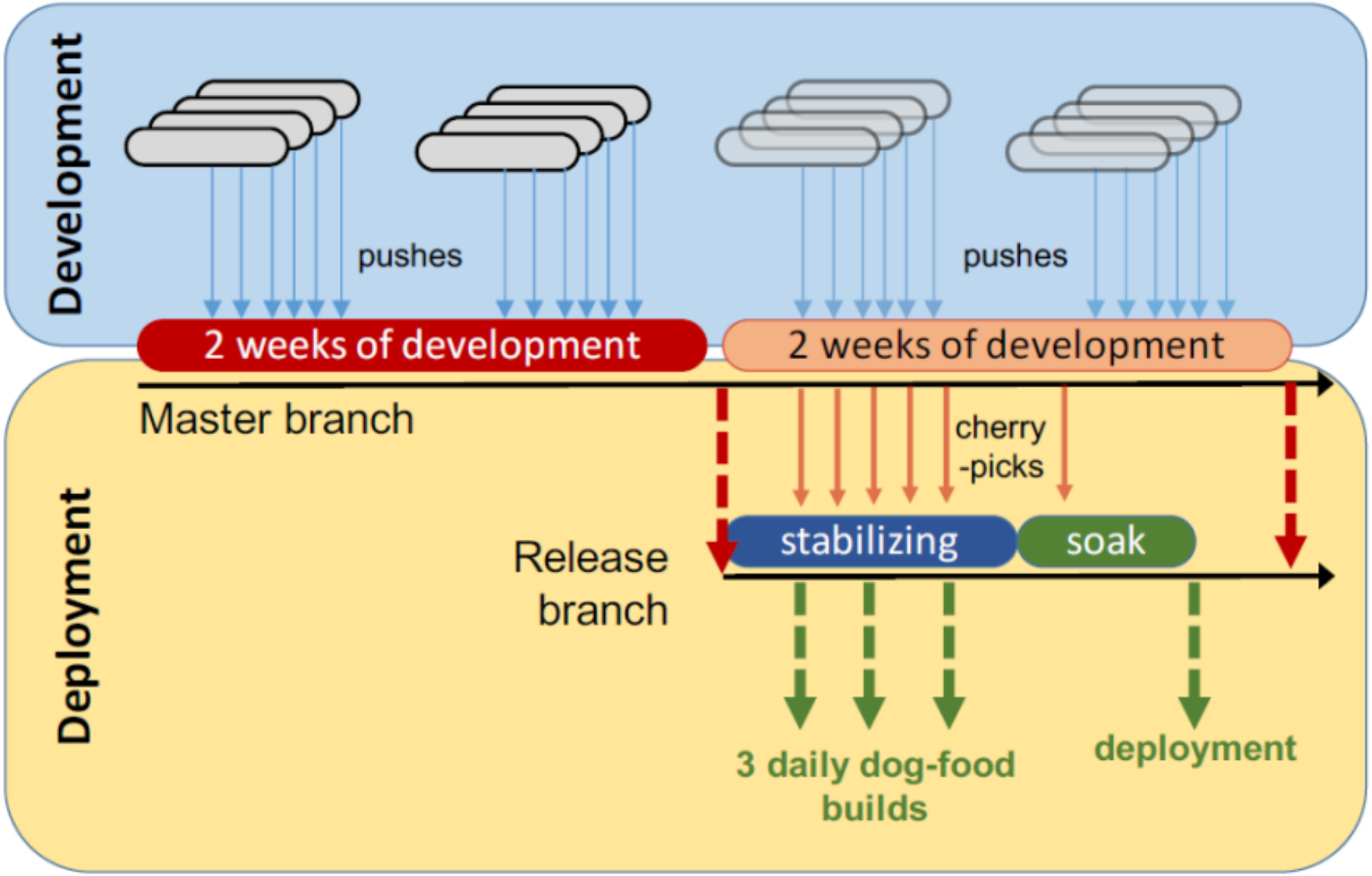
Branching

- Parallel copies of the source tree
- Can be changed independently, versioned separately, and merged later (or left separate)
- Often used for exploratory changes or to isolate development activities
- Many usage patterns, common:
  - Main branch for maintenance OR main development
  - New branches for experimental features; merge when successful
  - New branches for nontrivial maintenance work
  - Branches for maintenance of old versions

Release management with branches



Release cycle of Facebook's apps



Variants and Revisions

- **Revision** replaces prior revision (temporal)
- **Variant** coexists with other variants
- **Version** describes both
- **Release:** Published and named version

	V1.0	V1.1	V2.0	V3.0
Base system (Windows)	X	X	X	X
Linux variant		X	X	
Server variant			X	X
Extension for customer A		X	X	X
Extension for customer B				X

Semantic Versioning for Releases

- 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.

http://semver.org/

Managing variants

- Branching for variants does not scale well
- Requires special planning or tooling

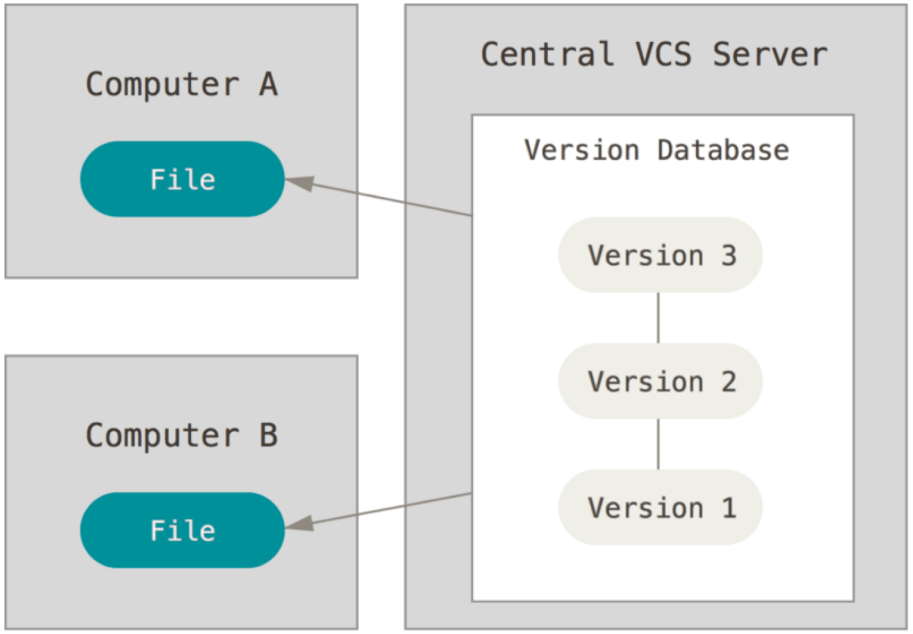
- Many solutions
  - Configuration files
  - OO polymorphism
  - Preprocessors
  - Build systems
  - DSLs
  - Software product lines
  - …

```
/* common parts */
...
/* dependent on operating system */
#if (OS == Unix)
...
#elif (OS == VMS)
...
#else
...
#endif
...
```

C. TYPES OF VERSION CONTROL

Centralized version control

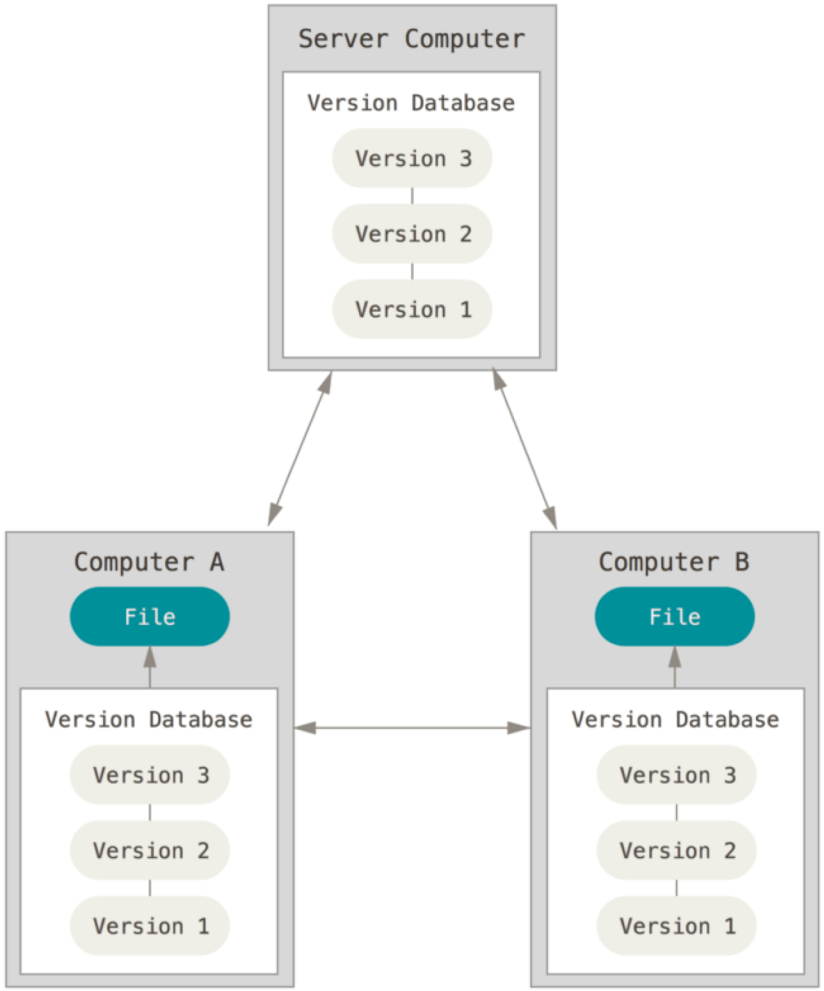
- Single server that contains all the versioned files
- Clients check out/in files from that central place
- E.g., CVS, SVN (Subversion), and Perforce



https://git-scm.com/book/en/v2/Getting-Started-About-Version-Control

Distributed version control

- Clients fully mirror the repository
  - Every clone is a full backup of ***all*** the data
- E.g., Git, Mercurial, Bazaar



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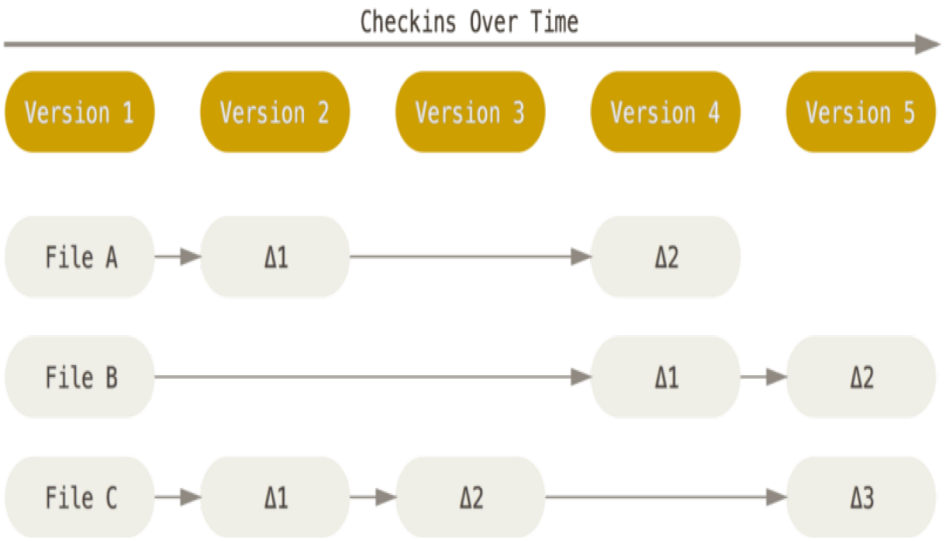
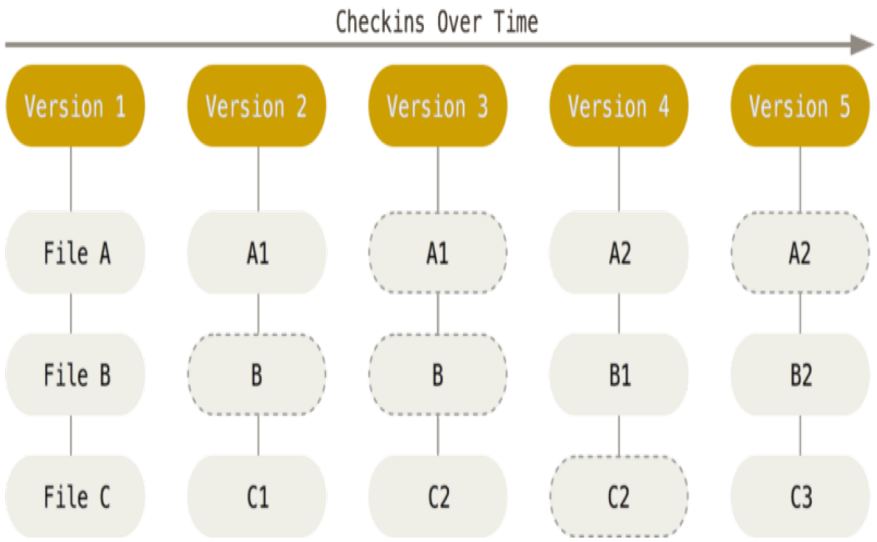
SVN (left) vs. Git (right)





- SVN stores changes to a base version of each file
- Version numbers (1, 2, 3, …) are increased by one after each commit

- Git stores each version as a snapshot
- If files have not changed, only a link to the previous file is stored
- Each version is referred by the SHA-1 hash of the contents

https://git-scm.com/book/en/v2/Getting-Started-About-Version-Control

Which files to manage (both types)

- All code and noncode files
  - Java code
  - Build scripts
  - Documentation
- Exclude generated files (.class, …)
- Most version control systems have a mechanism to exclude files (e.g., .gitignore)

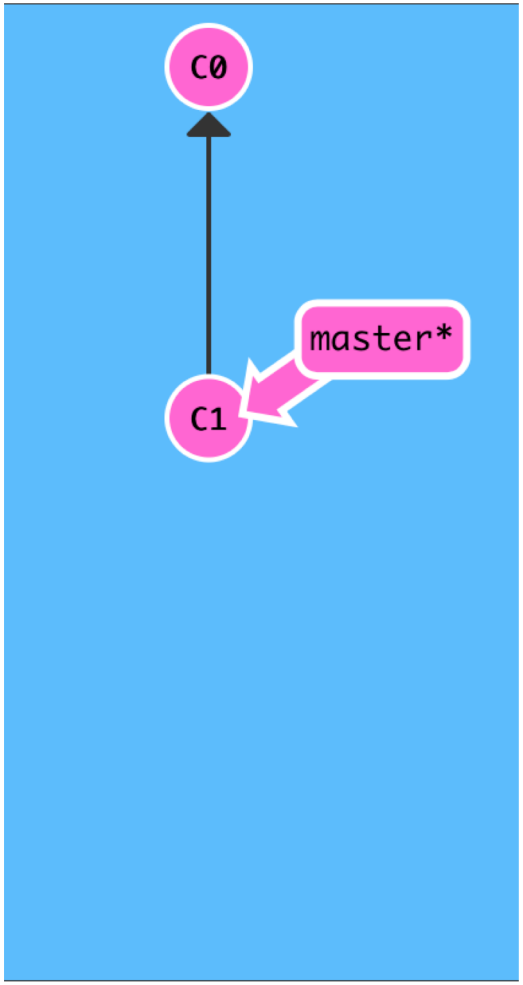
Activity

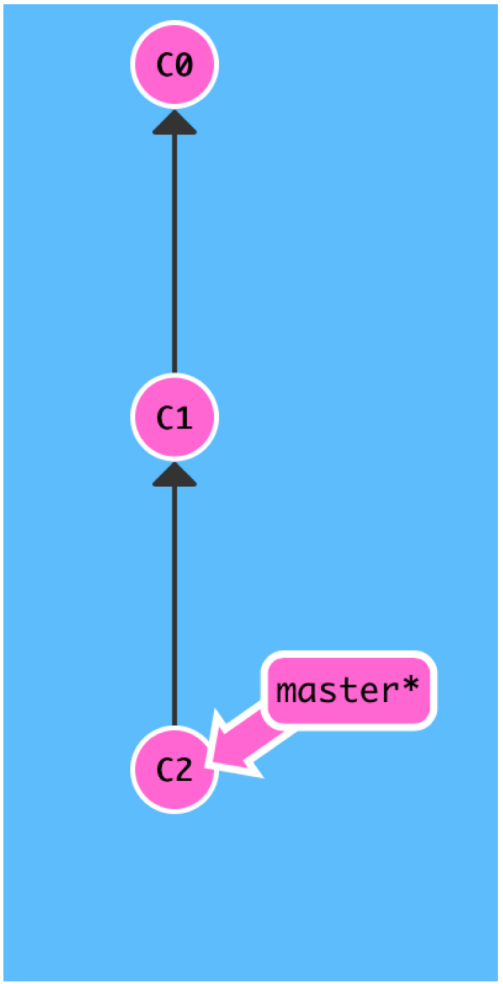
- In pairs, discuss advantages and disadvantages of centralized (e.g., SVN) vs decentralized (e.g., git) version control

D. GIT BASICS

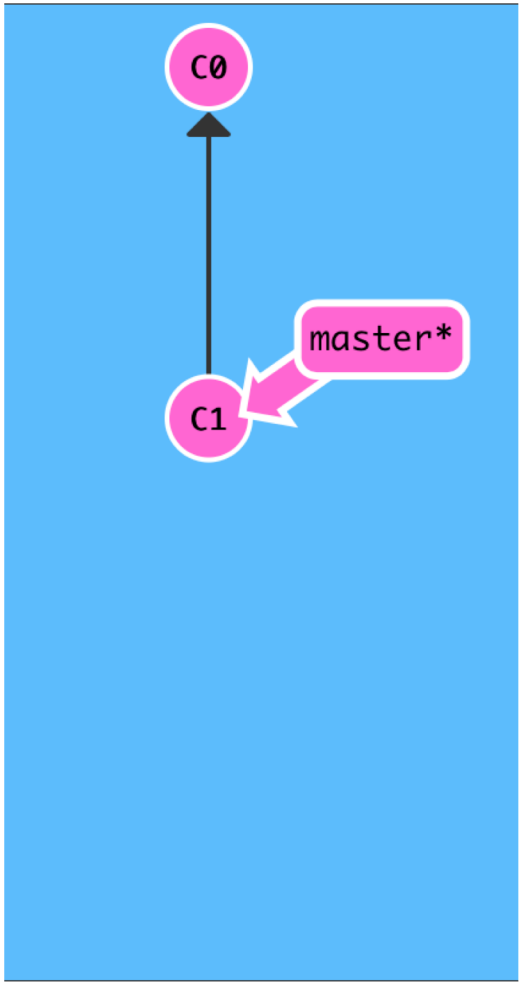
Graphics by https://learngitbranching.js.org

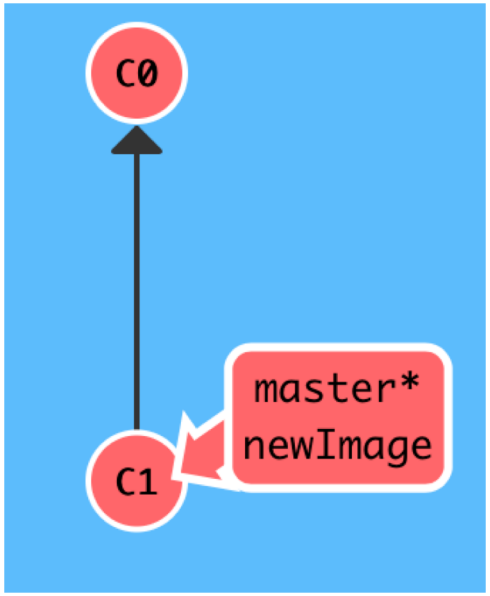
git commit



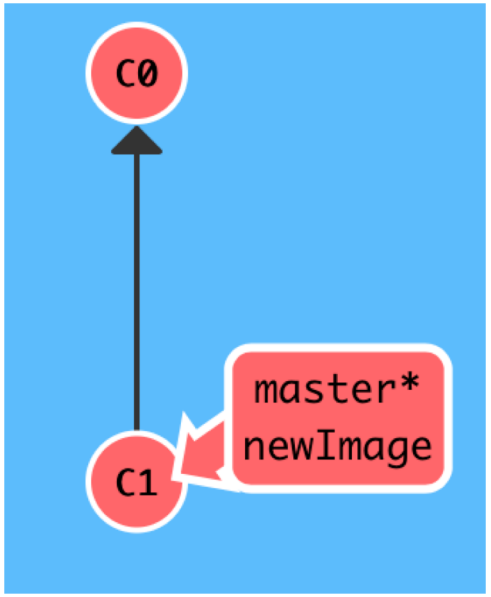


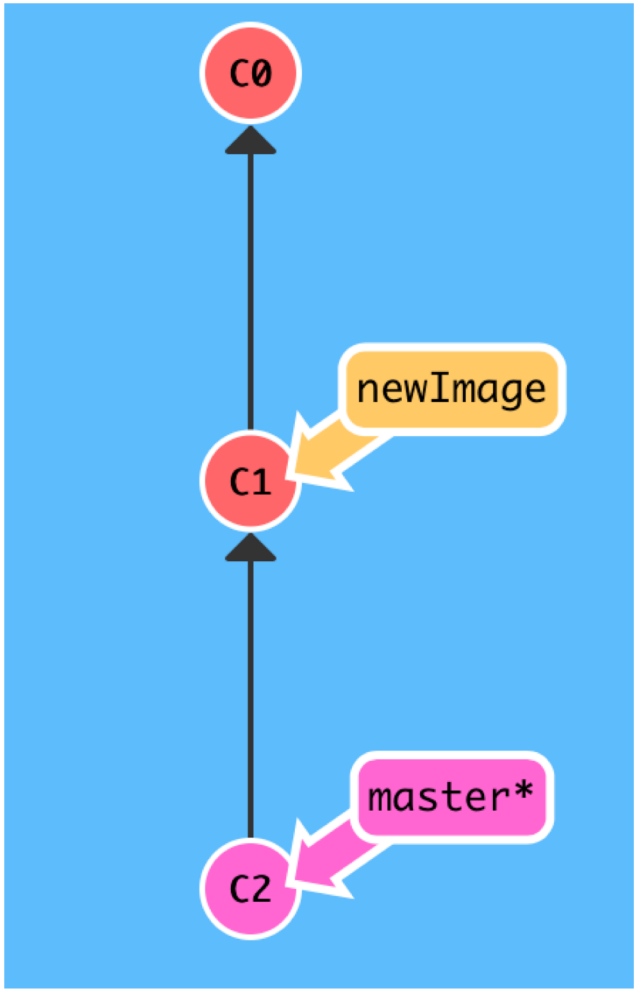
git branch newImage



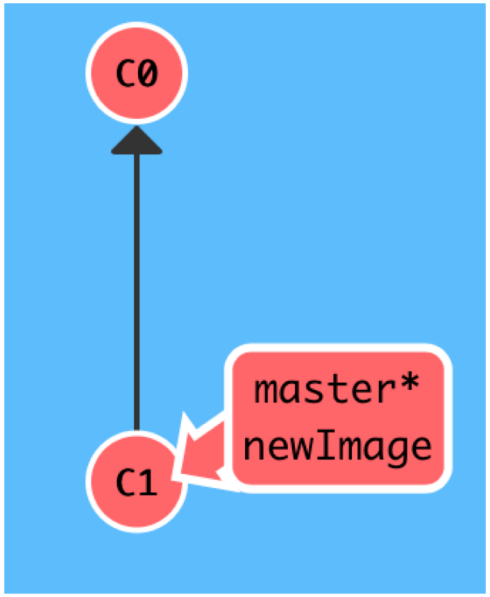


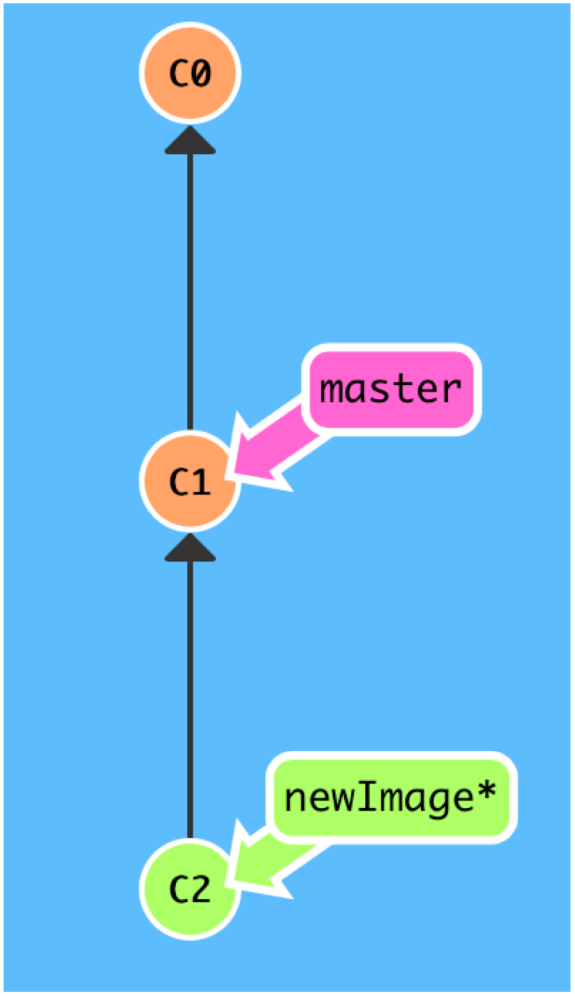
git commit



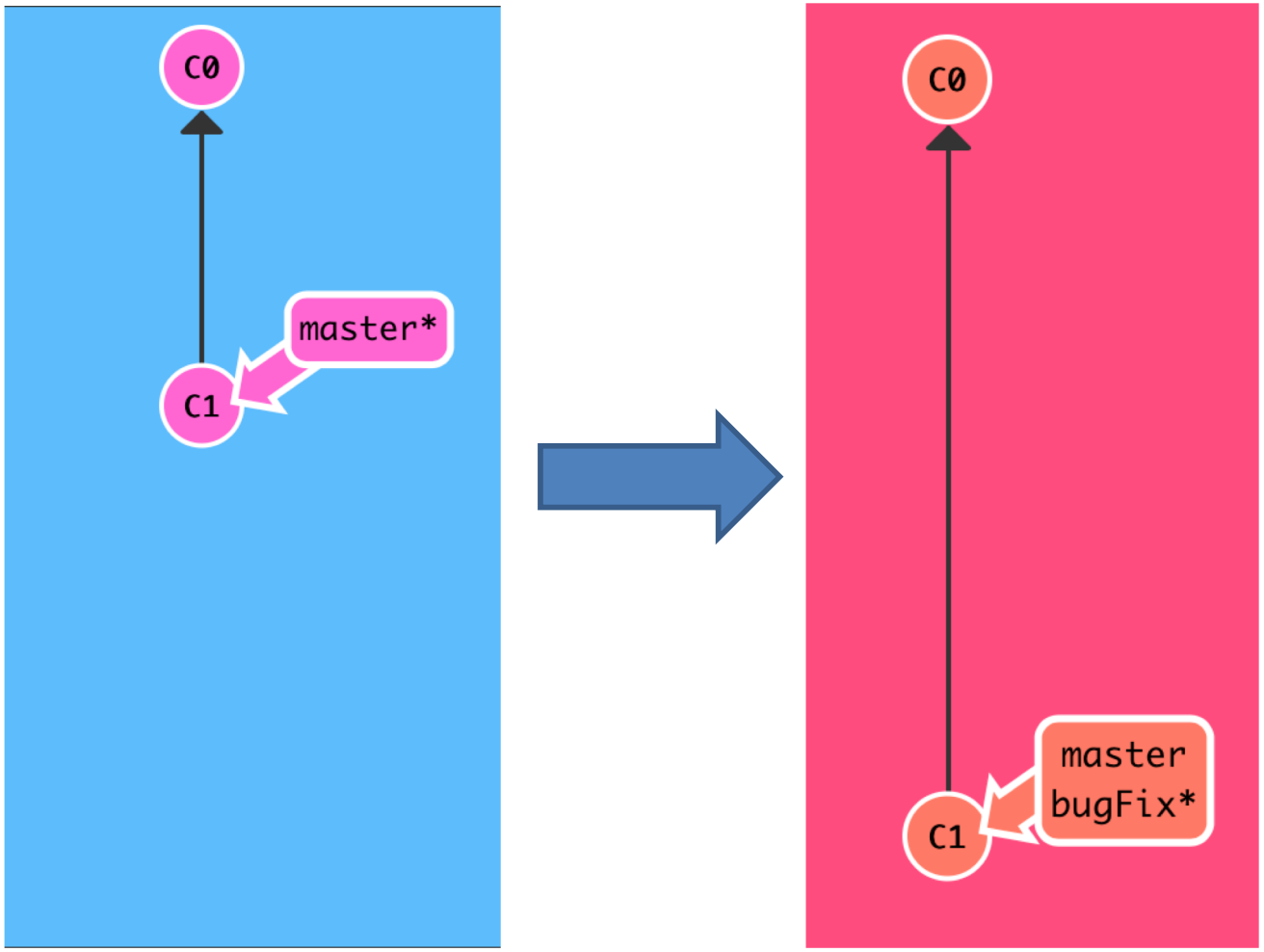


git checkout newImage; git commit

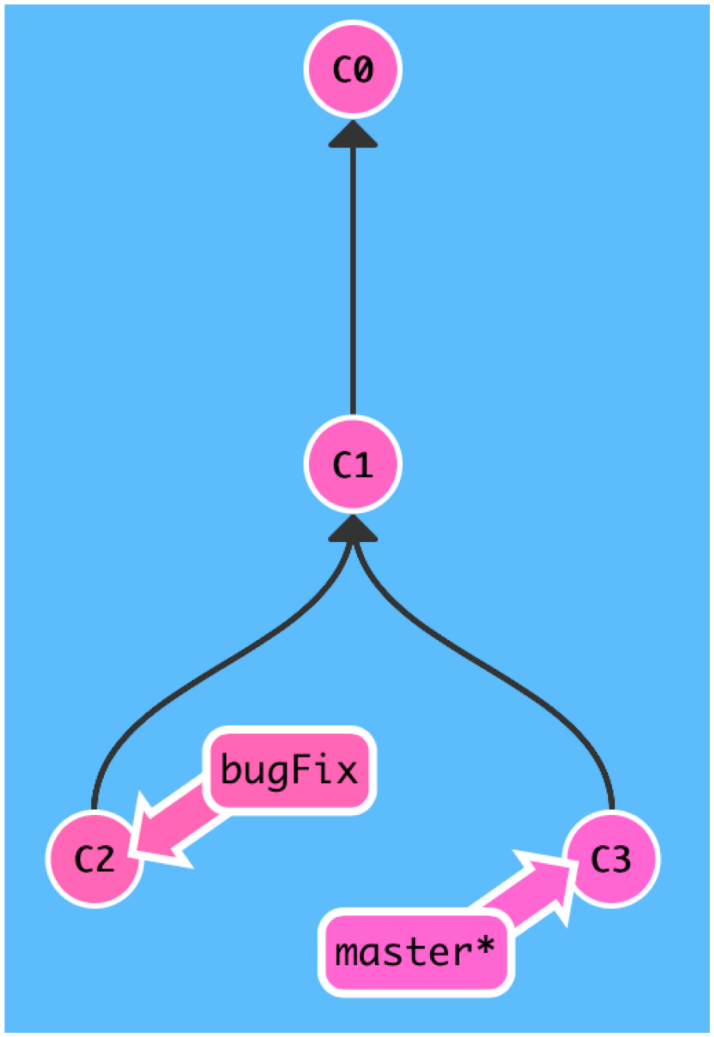


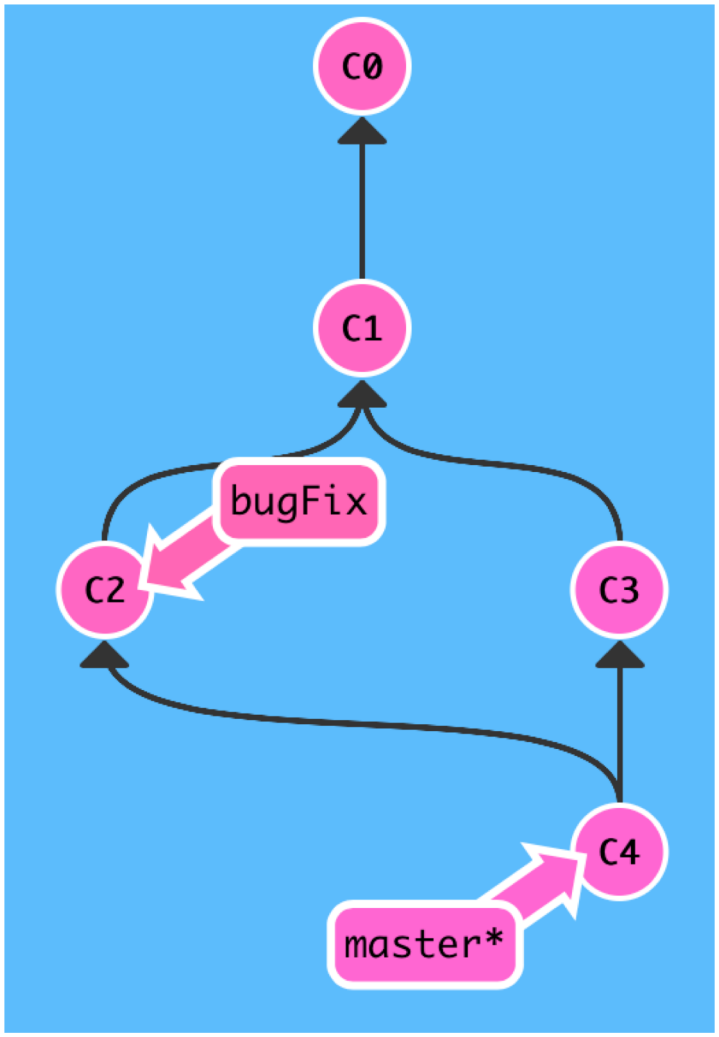


Activity: Make a new branch named bugFix and switch to that branch

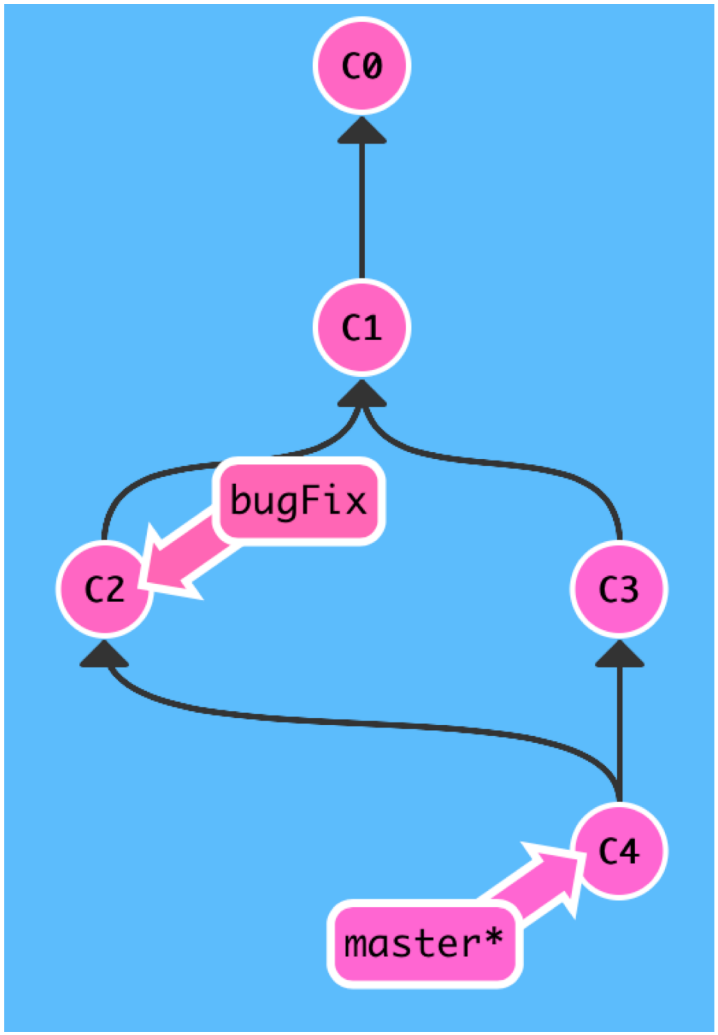


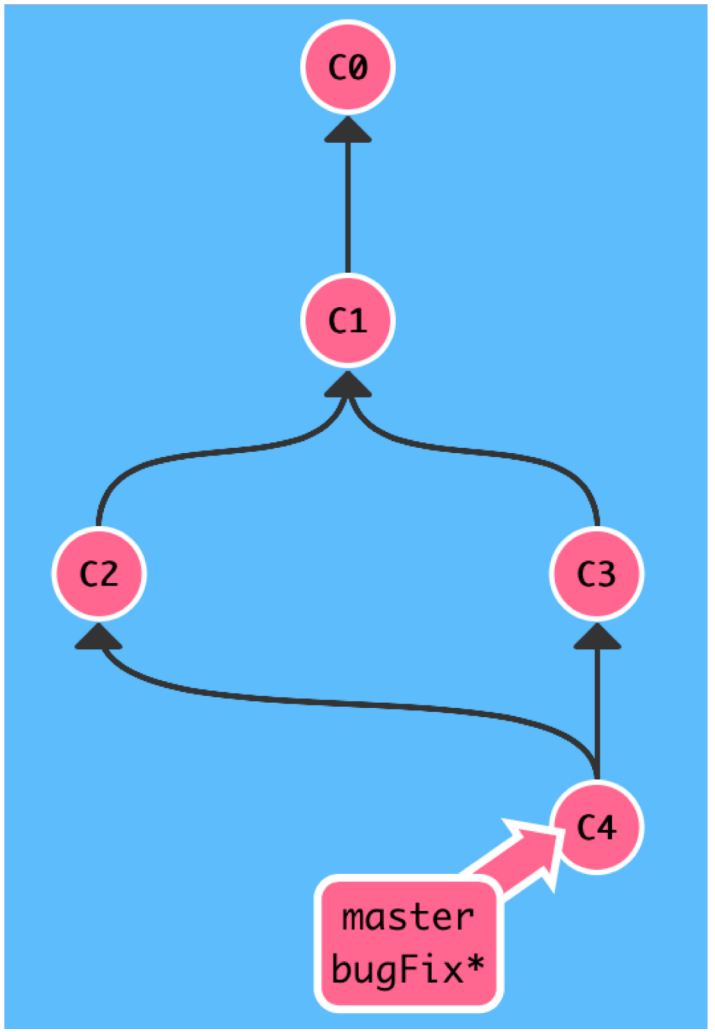
1) git merge bugFix



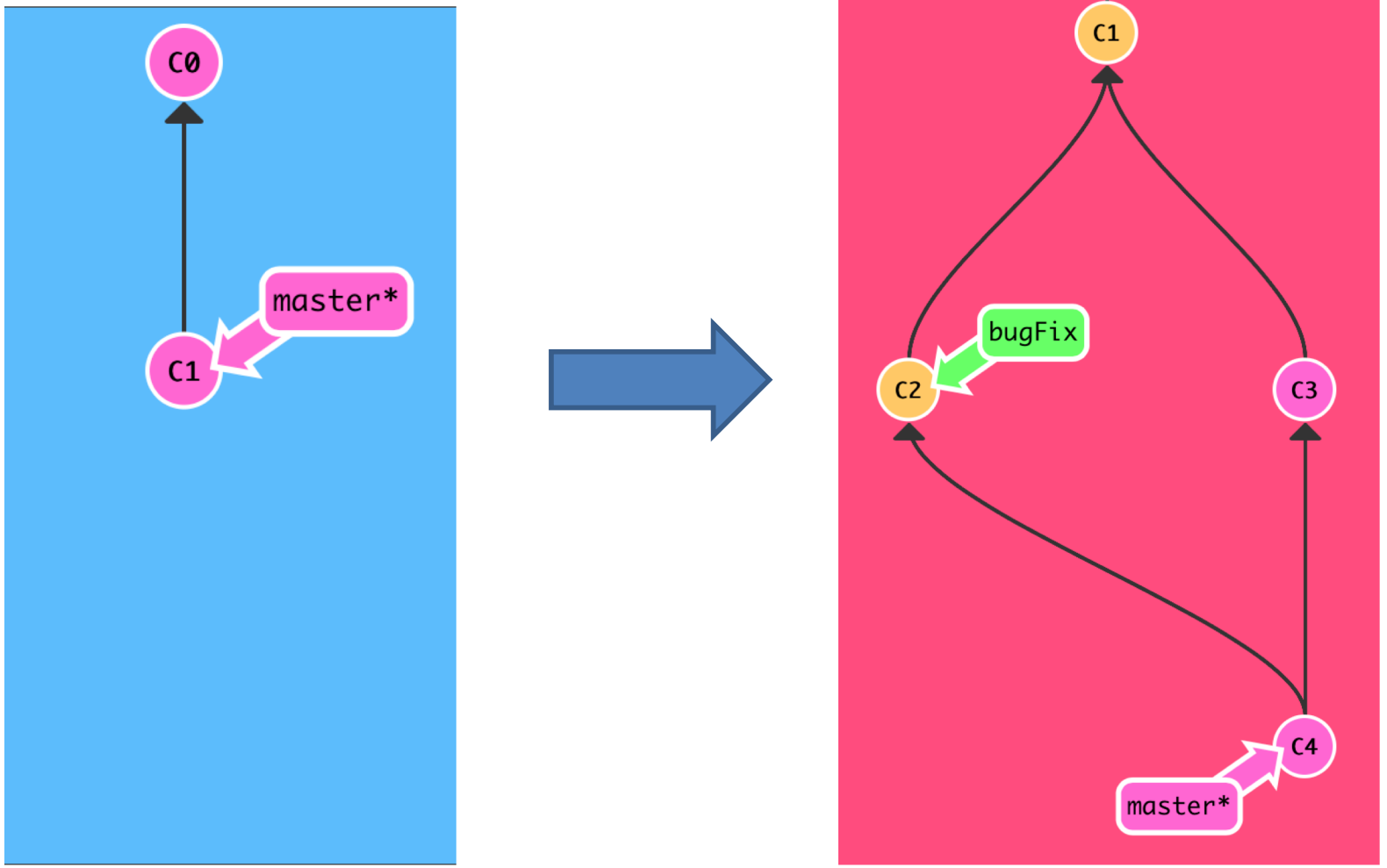


git checkout bugfix; git merge master



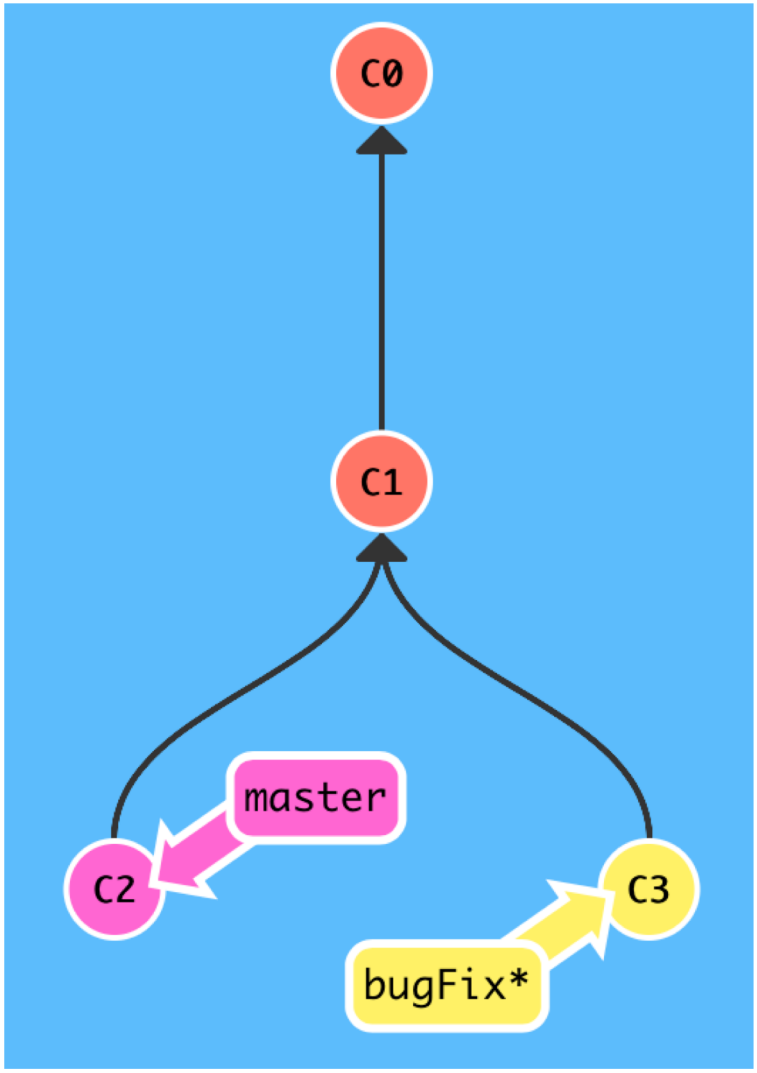


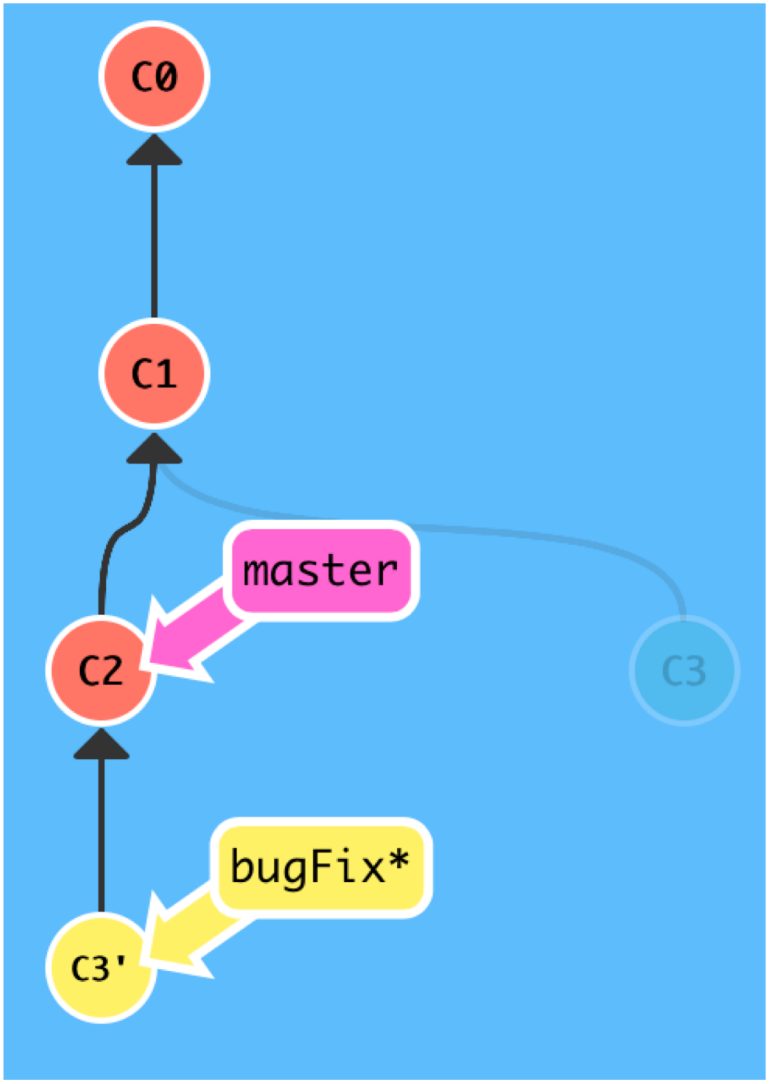
Activity:



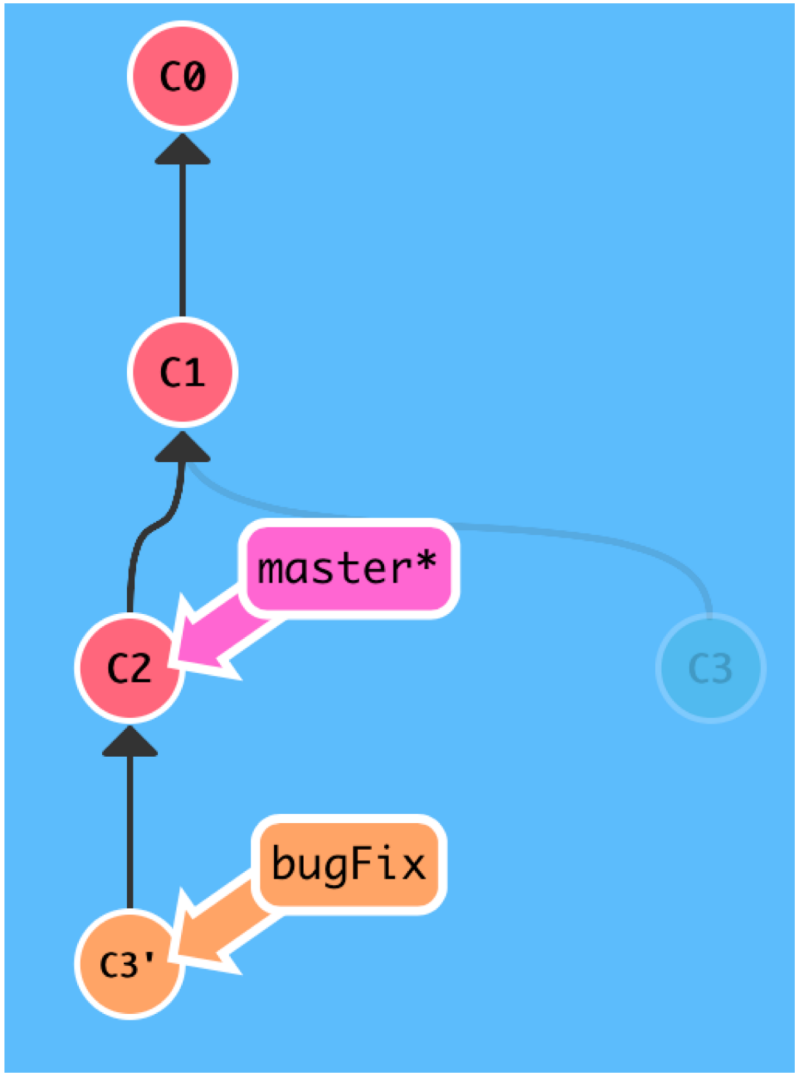
2) git rebase master

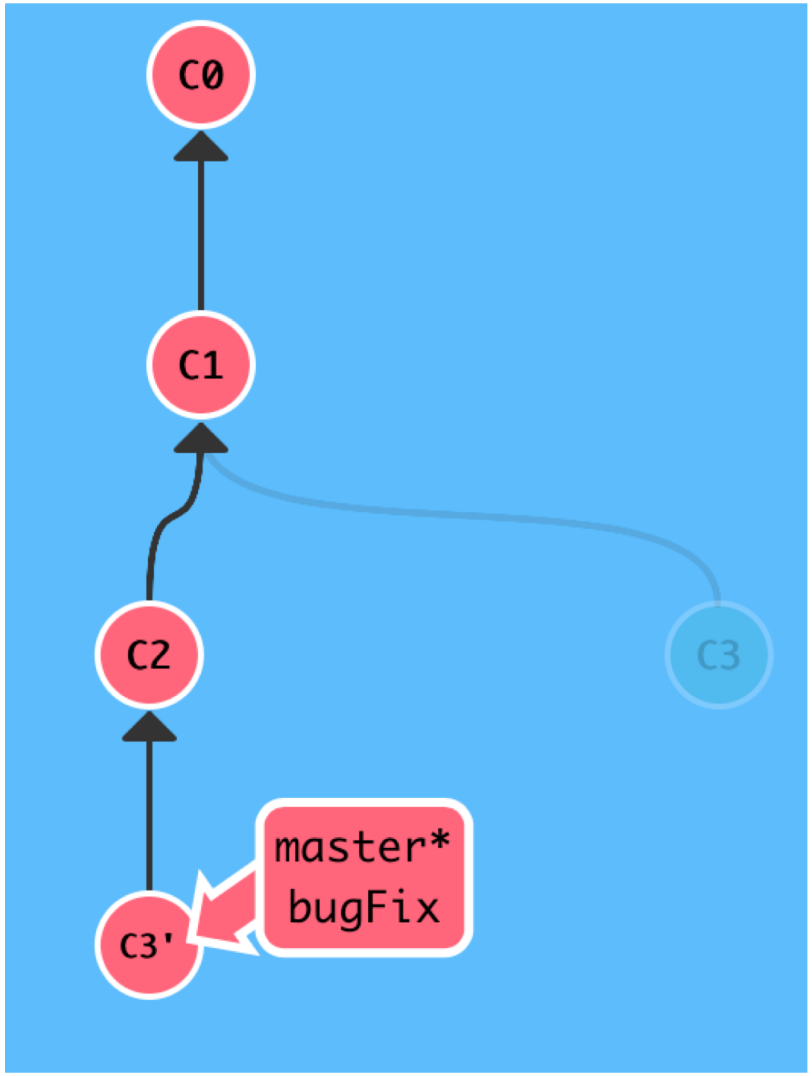
Move work from bugFix directly onto master





git rebase bugFix





To be continued …

Summary

- Version control has many advantages
  - History, traceability, versioning
  - Collaborative and parallel development
- Locking vs. merging and merge conflicts
- Collaboration with branches
- From local to central to distributed version control