Version Control

Martin Kellogg

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Today's agenda:

- **Reading Quiz**
- Finish discussion of testing
- How does a version control system work?
- How to use your VCS
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Reading Quiz: version control

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A. It includes the names of all modified files, so it’s easy to see what’s changed

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Lens of Logic: test input generation plan

- Recall: we want to automatically generate **test cases**
- We have an approach that works well in practice:
  - **Enumerate** some paths
  - **Extract** their path constraints
  - **Solve** those path constraints
- What are we **missing**?
  - Oracles!

Review: implicit oracles

Observation: there are some things programs definitely shouldn't do given **any** input

- crash, segfault, loop forever, exfiltrate user data, etc.
- **key idea**: run the program and check if it does any of these **definitely bad** things

Definition: an ***implicit oracle*** is one associated with the language or architecture, rather than program-specific semantics (e.g., "don't segfault", "don't loop forever").

Review: invariants as oracles

Observation: programs **usually** behave correctly

- e.g., if I have a human-written test suite with ten tests, and we have `index == array_len - 1` in **every test**
- then maybe the correct oracle is that on **every input** we should have `index == array_len - 1`

Definition: an ***invariant*** is a predicate over program expressions that is true on every execution

- high-quality invariants can serve as test oracles

Oracle generation: differential testing

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Can you think of other examples of situations where differential testing is applicable?

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  - and sometimes neither is!
- but, differential testing provides a **much stronger oracle** than other automated techniques

Test input generation

- As a human, often **choosing good test inputs** is the hardest part of writing a test
- For a computer, that's not true: computers can pick inputs **very fast** (given some policy)
- **Key problem**: which inputs should we pick?
  - Lens of **Logic**: choose inputs that will maximize coverage
  - Lens of **Statistics**: choose inputs "at random"
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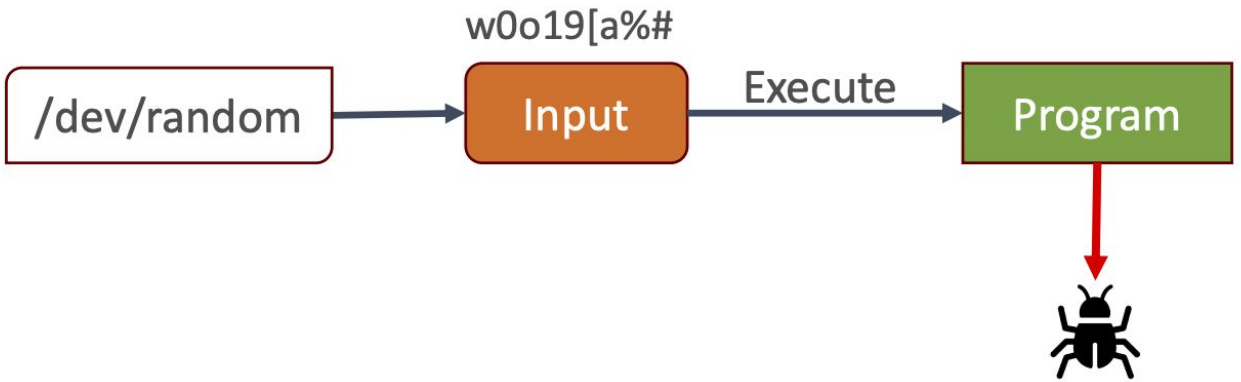

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  - so modern fuzzers use some kind of **semi-random, directed search**

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- Fuzzing **finds real bugs**
  - especially useful for finding security bugs

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Lens of Adversity: killing mutants

- Actually, **not as useful as it seems** for automatic test generation
  - still need to use either path predicates or fuzzing to choose inputs
- Can be a useful **fitness function** or guide for other automated test input generation approaches

Takeaways: Automated Test Generation

- Two typical ways to generate test inputs:
  - solve path constraints
  - “at random” via fuzzing
- Both common in practice
- Both suffer from the oracle problem
  - implicit oracles are most common solution
  - invariants, differential testing, etc. also options

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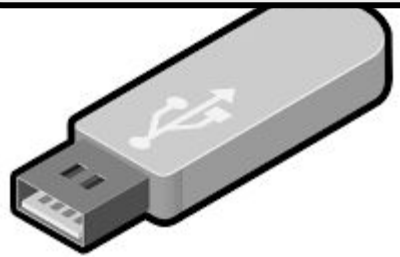

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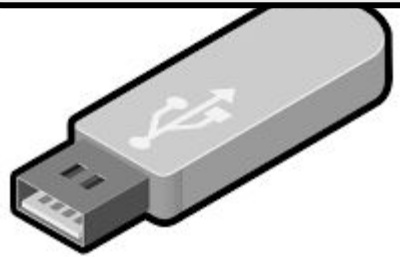

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- **Coordinate**/merge work between team members
  - Or yourself, on multiple computers, or multiple features

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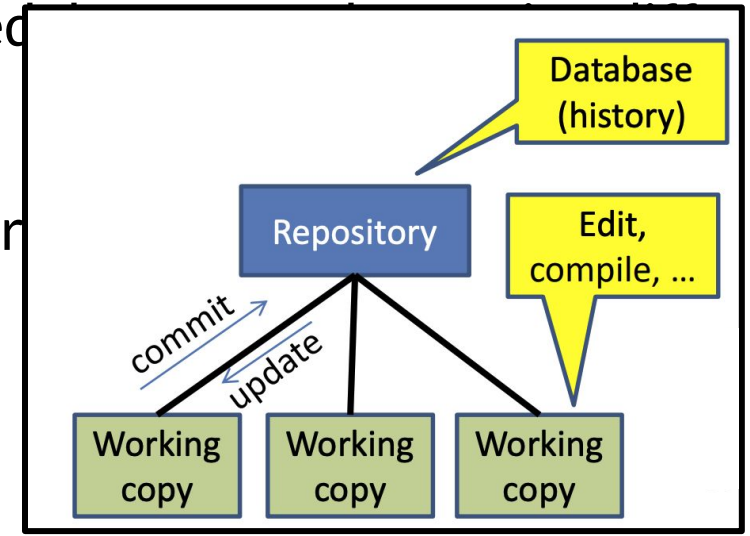

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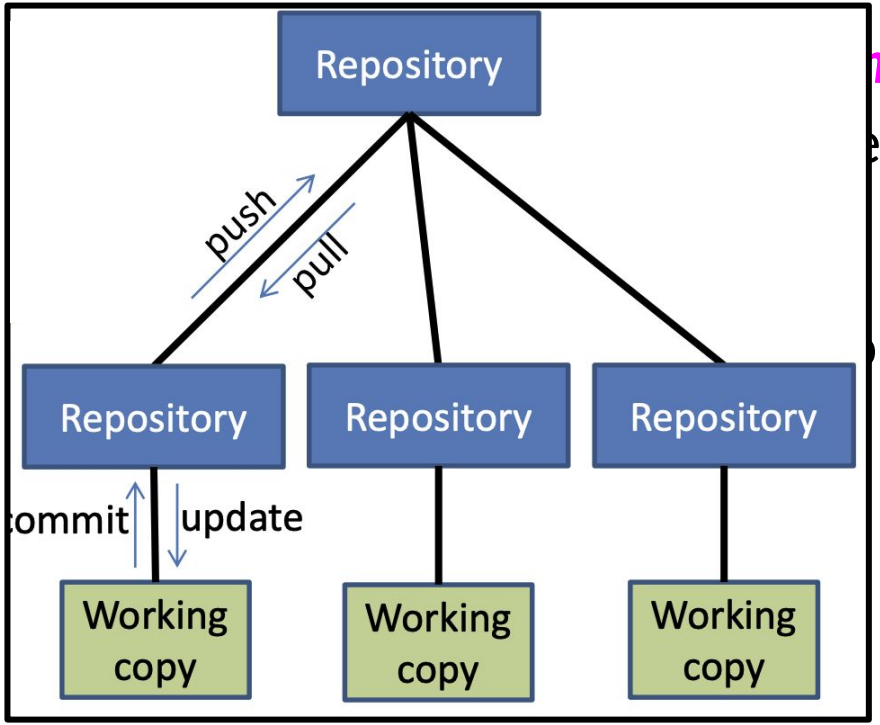

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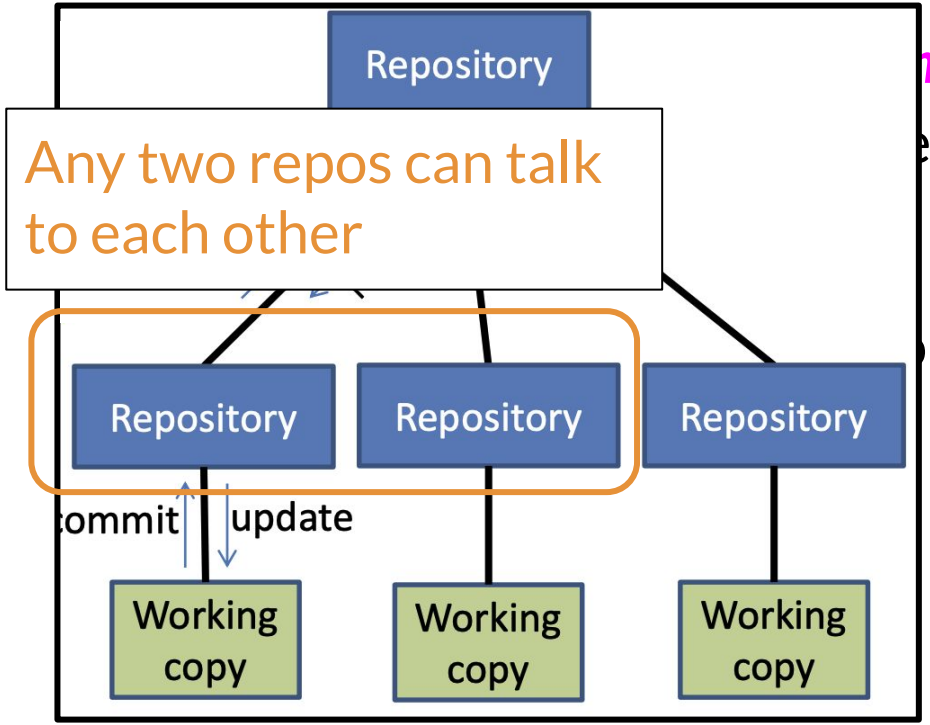

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typical setup: distributed VCS with a single, privileged main

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Distributed VCS is now the **industry standard** (e.g., git, hg). (Some organizations do still use centralized, though.)

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- No update if uncommitted changes exist: must commit first
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- Rationale:
  - Maintain more accurate, complete history
  - Keep all users in sync
  - Avoid painful conflicts
  - Avoid loss of work

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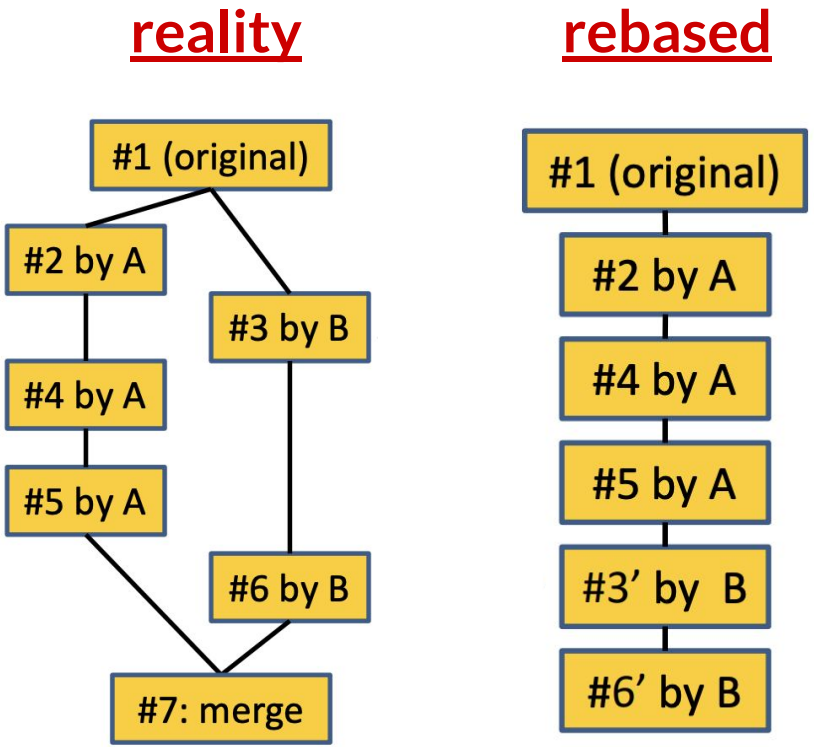

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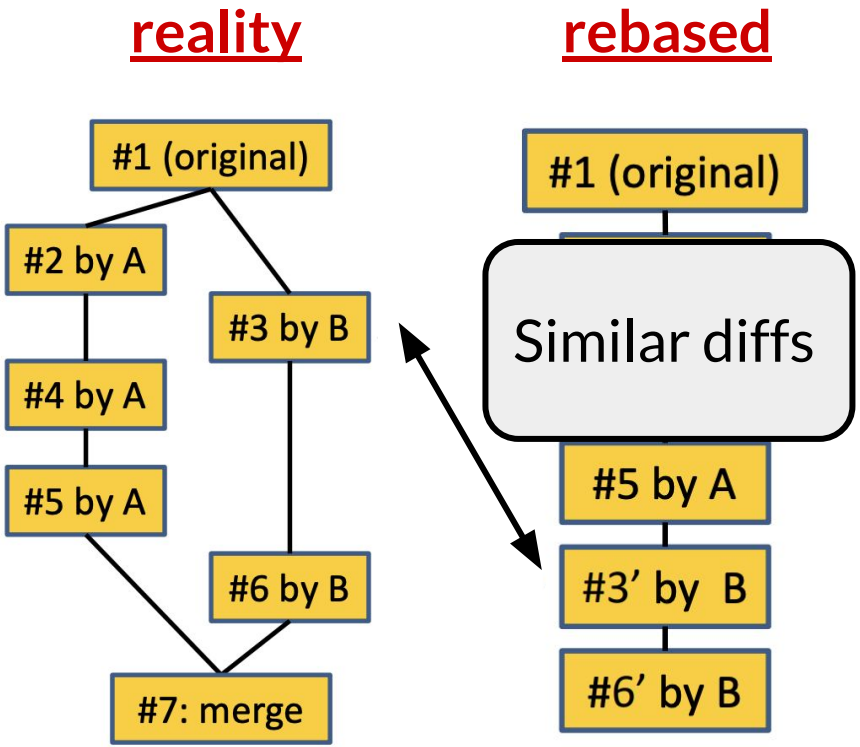

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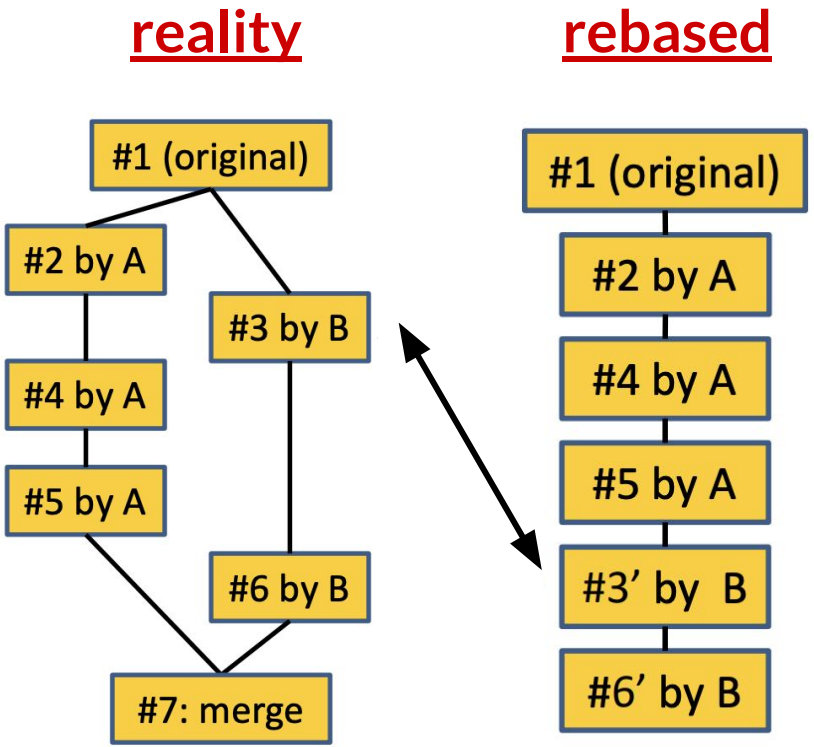

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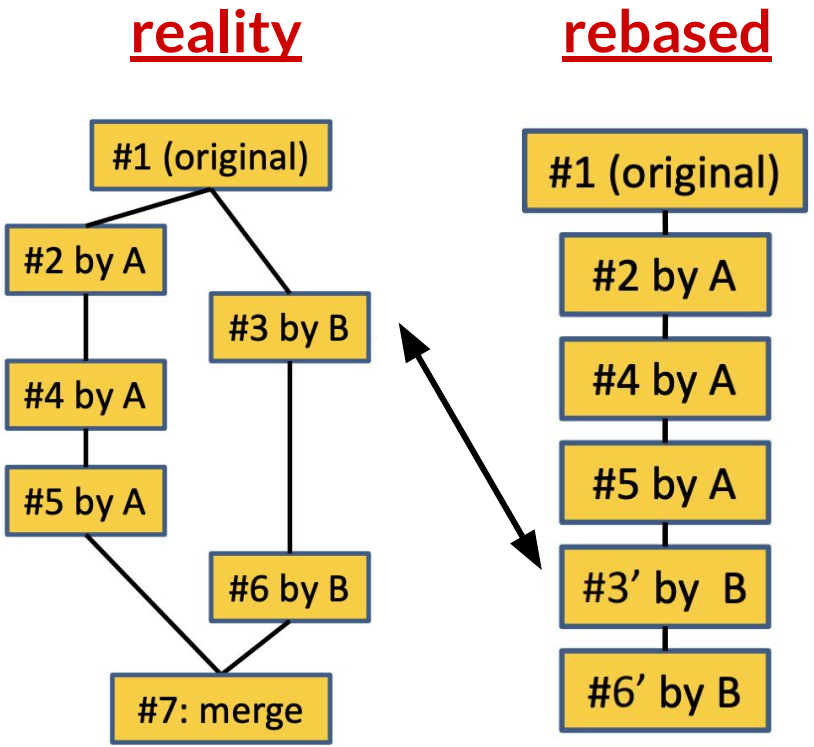

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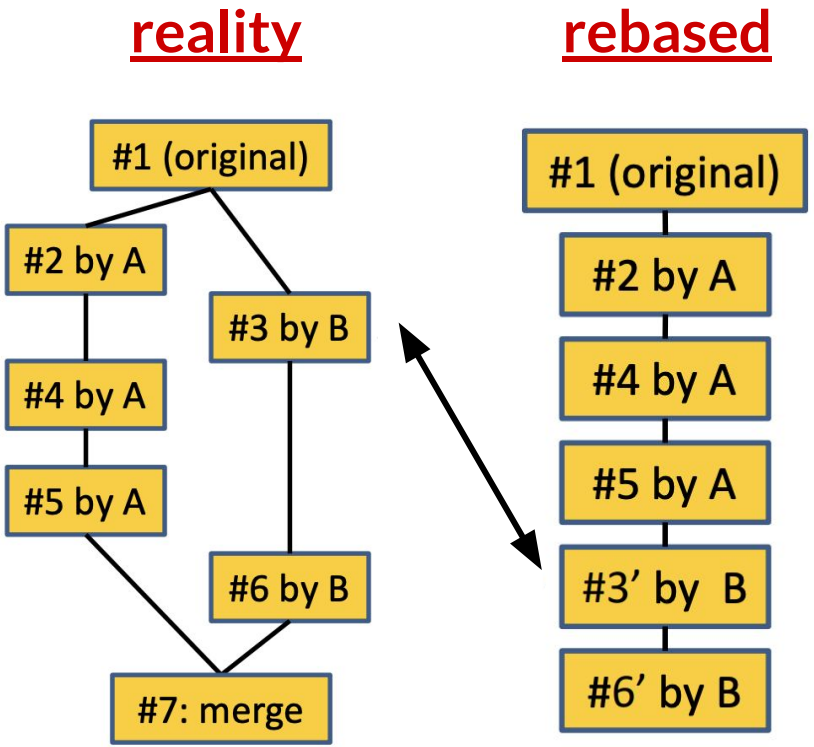
- Squash-and-merge is a safer form of rebasing



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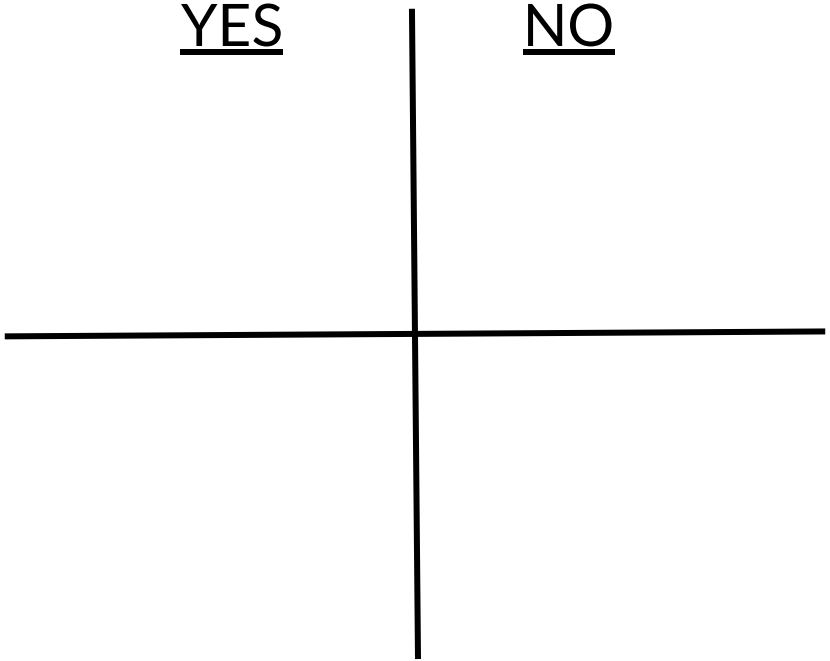
“Conflict-free” is a **textual**, **not semantic**, notion

- A heuristic about when to get the user involved
- Could yield compile errors or test failures

Aside: false positives and false negatives

Can X **actually** happen?



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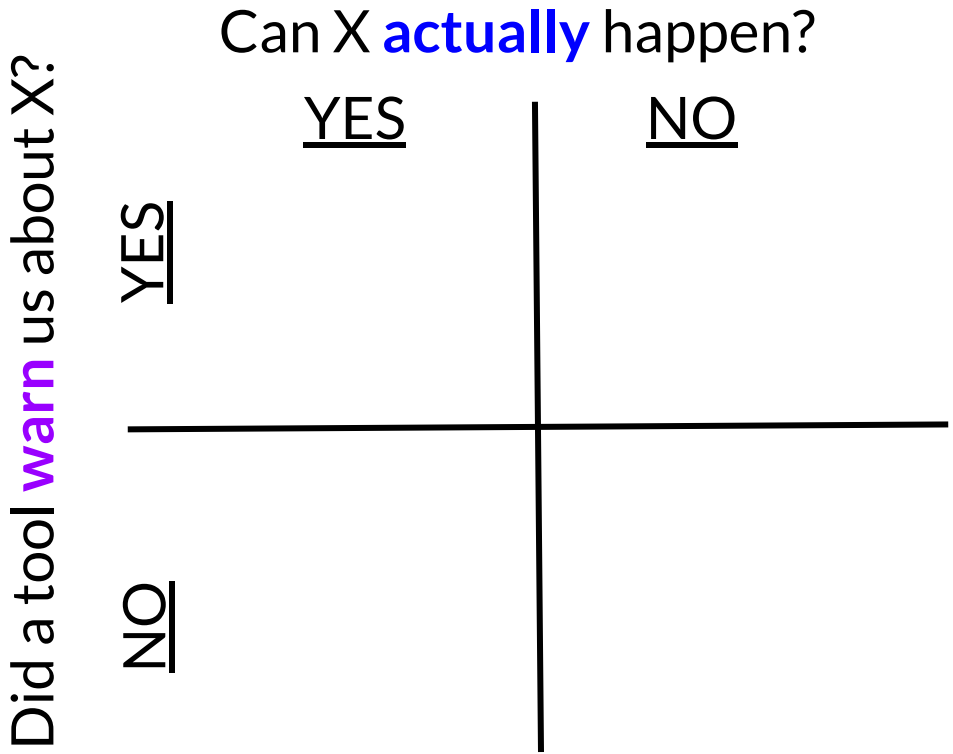

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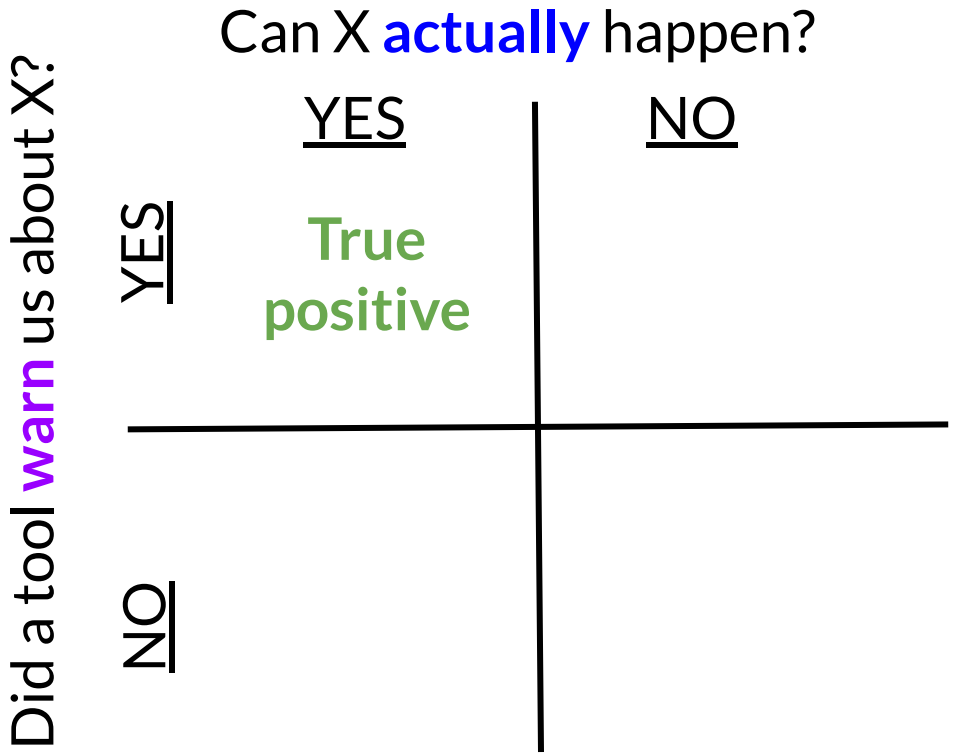

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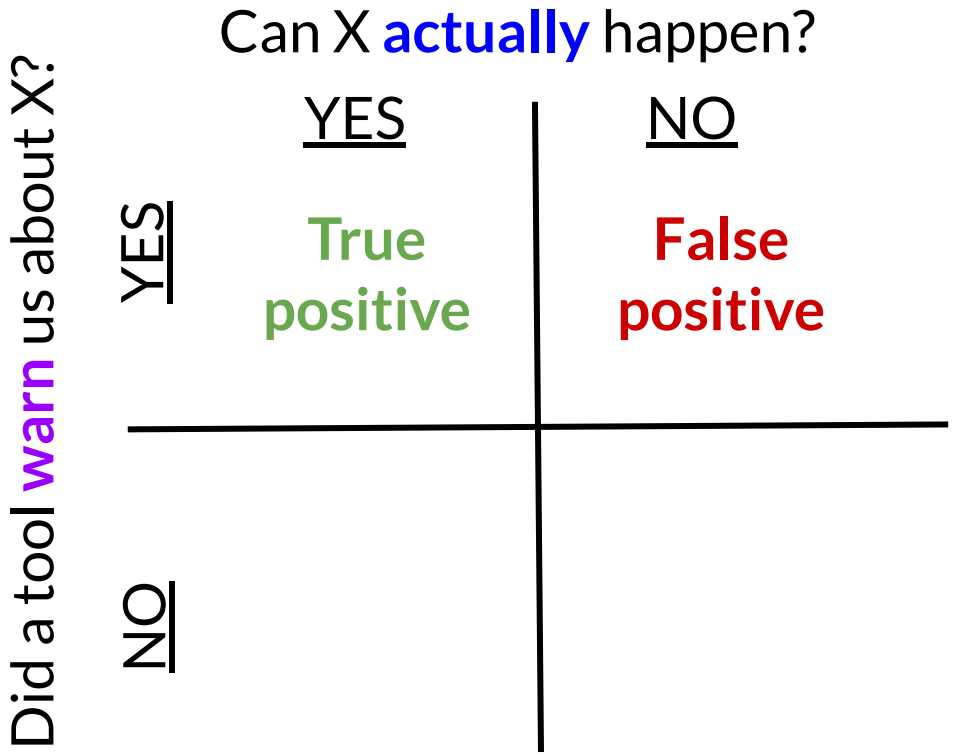

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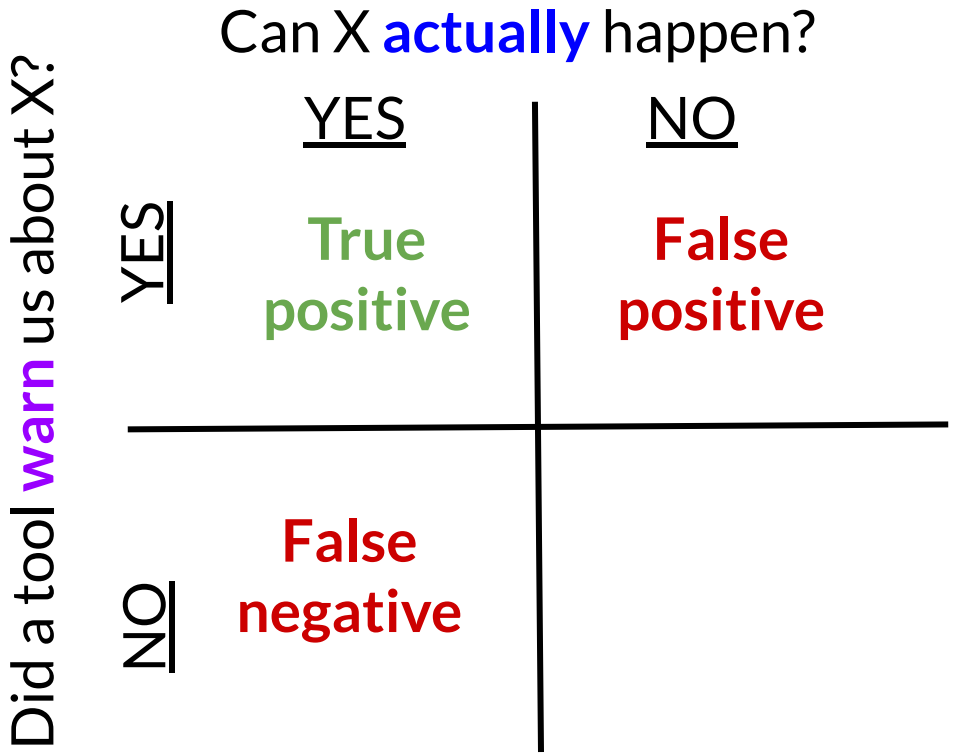

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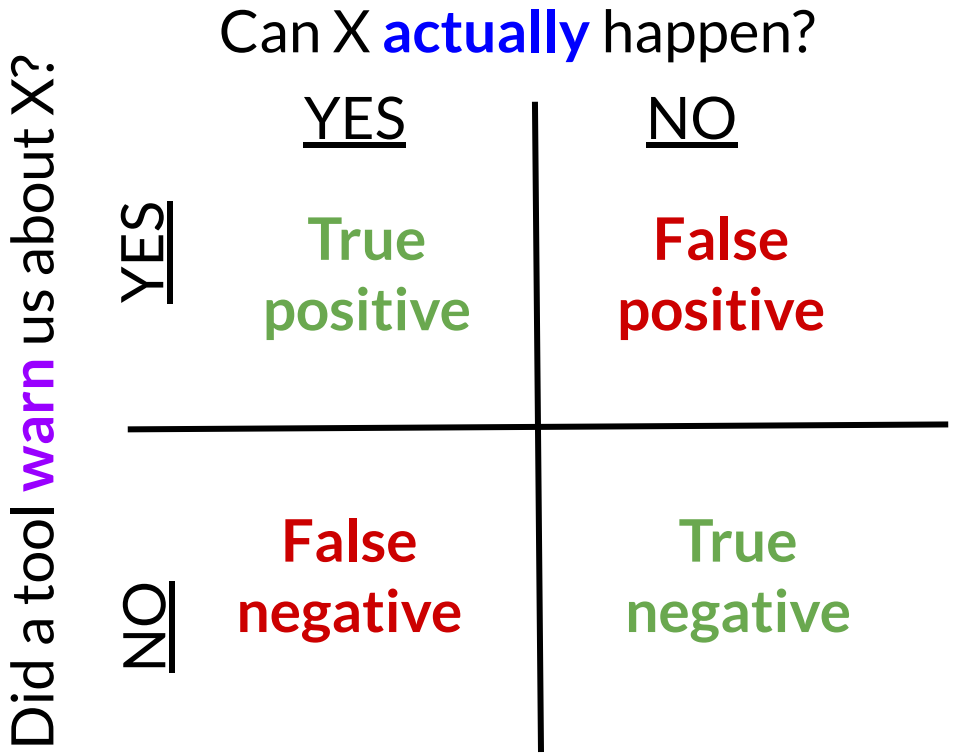

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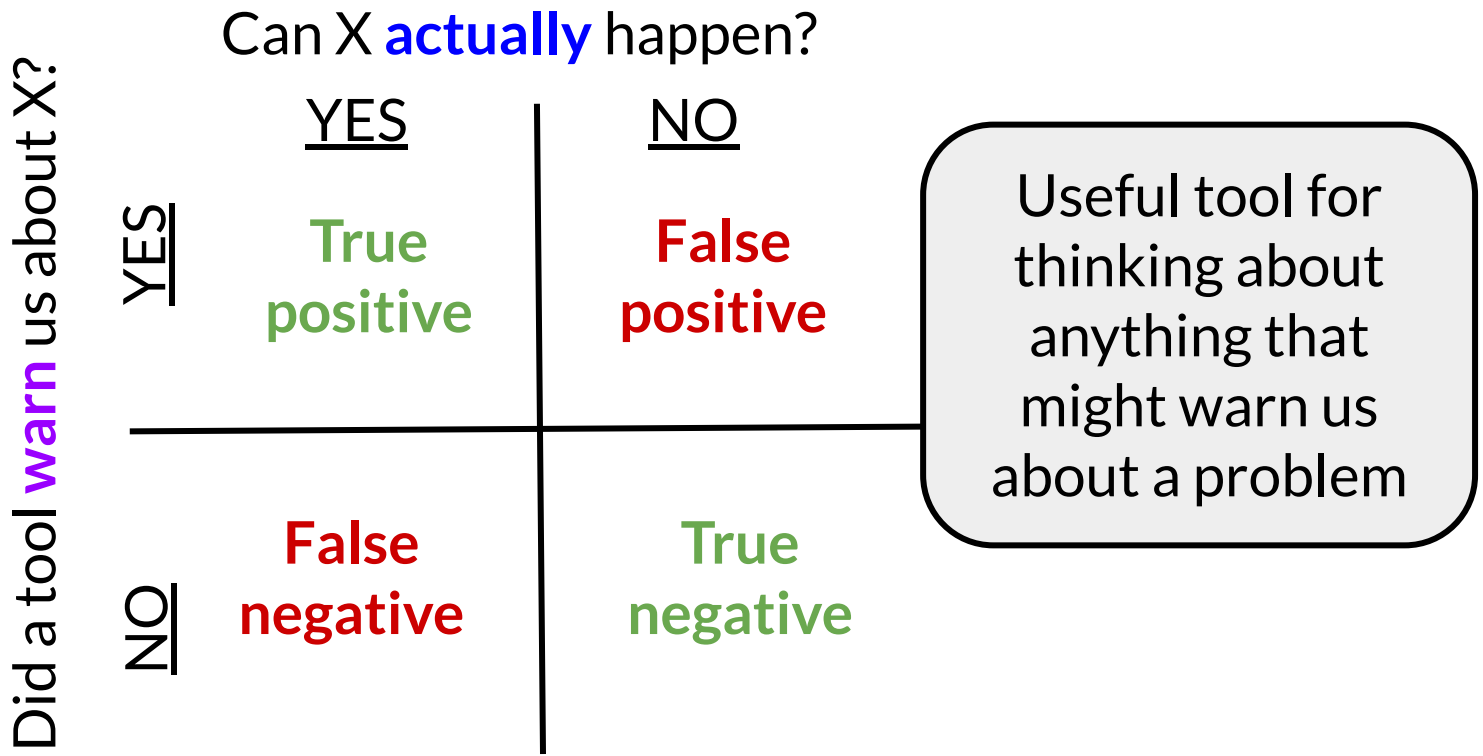

Coordinating with others: conflicts

Two changes can either be:

- **Conflict-free**: changes are to different lines of a file
- **Conflicting**:
  - Simultaneous changes to the same
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False positives, false negatives, both, or neither?

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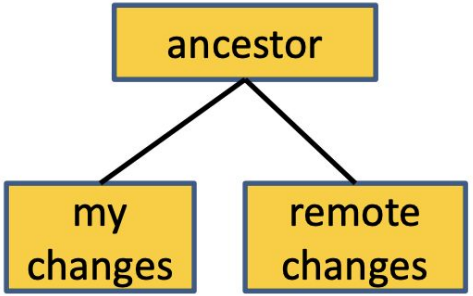

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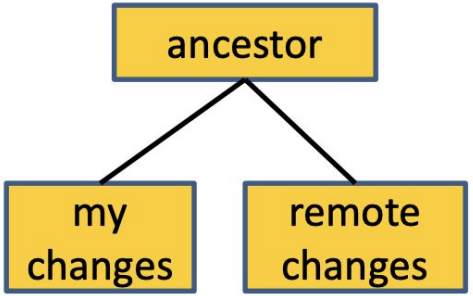
  - **Practice** this ahead of time!



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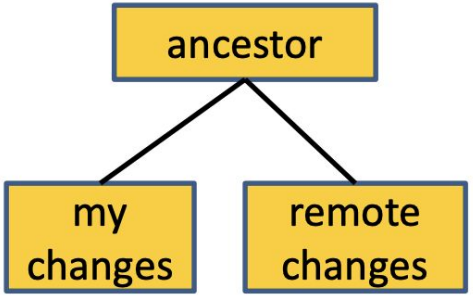
- **Don't panic!** Instead, think.
- **You can always** bail out of the merge and **start over**
  - You have the full local and remote history



Version Control

Today’s agenda:

- Reading Quiz
- How does a version control system work?
- **How to use your VCS**
- GitHub workflows

Version Control: advice and best practices

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  - Wastes space in repository
  - Causes merge conflicts

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Advice: use feature branch development model iff your team typically ships features quickly

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  - Avoid difficult and/or complex merges
- Push as often as practical
  - Don’t let your teammates get behind you!
  - Don’t destabilize the main build
  - Avoid long periods working on a branch
    - but do work in a feature branch - don’t work directly on main!

Advice: commit messages

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- Commit messages should be **descriptive**
- Don't write a novel: **summarize**. The code documentation in the commit should cover the rest.

Advice: commit messages: good or bad?

```
commit 763fe9cc335bb78ca45a608fa1f4c606713d5b44
Author:
Date:

    Simplify `getImmediateSubcheckerClasses()` implementation (#5579)
```

Advice: commit messages: good or bad?

```
commit 763fe9cc335bb78ca45a608fa1f4c606713d5b44
Author:
Date:

    Simplify `getImmediateSubcheckerClasses()` implementation (#5579)
```

GOOD: short and to the point. Contains link to the PR it was merged in

Advice: commit messages: good or bad?

```
commit 123317b24a72215071a0f02e08635ee4b5b9669a
Author:                                                    noreply.github.com>
Date:

    Update the code (#5)
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commit 123317b24a72215071a0f02e08635ee4b5b9669a
Author:                                                  noreply.github.com>
Date:

    Update the code (#5)
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NOT SO GOOD:
description is vague
(looks auto-generated!)

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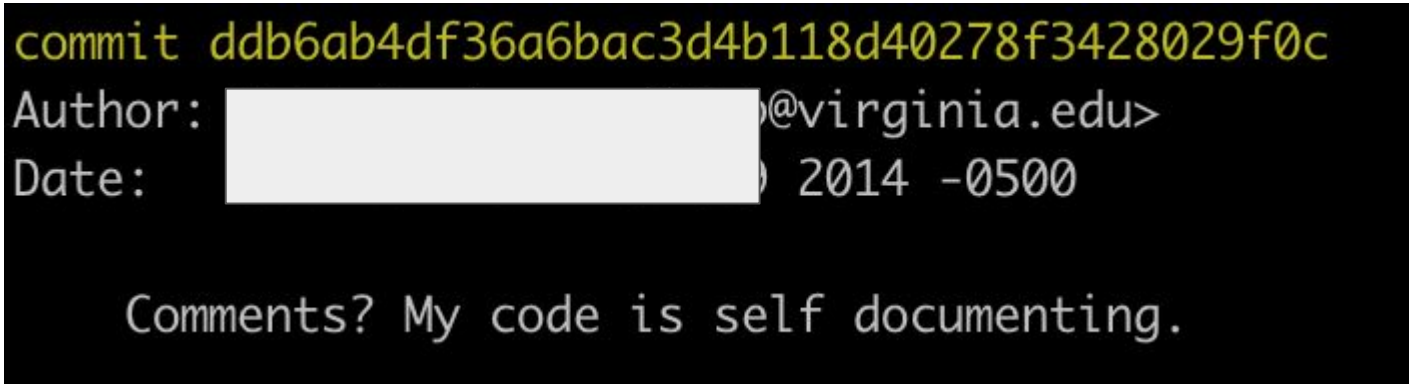

Advice: commit messages: good or bad?

```
commit ddb6ab4df36a6bac3d4b118d40278f3428029f0c
Author:                                  @virginia.edu>
Date:                                    2014 -0500

    Comments? My code is self documenting.
```

NOT SO GOOD: while the humor is nice, this message is content-free

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  - Create a branch for each simultaneous task
    - Need to keep track of all your branches, merge
    - Easier to share unfinished work with teammates

Advice: ways to avoid merge conflicts

- **Modularize** your work
  - Divide work so that individuals or subteams "**own**" a module
  - Other team members only need to understand its specification (abstractions!)
  - Requires good documentation and testing

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Bonus: this kind of modularization improves **observability** for management: it's easier to see who is being productive

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- **Communicate** about changes that may conflict
  - Don't overwhelm the team with such messages

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I use **text-based formats** for many files so that I can version control them

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- open PR against "**main**" repository from your fork's feature branch

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I've seen people make all of these mistakes (and more)!

Takeaways: version control

- Understand what your VCS is good for (storing text files, collaboration) and what it isn’t good for (storing binaries!)
- Understand your VCS: don’t just thoughtlessly use the GUI
- Follow best practices when using your VCS:
    - don’t push straight to main
    - practice resolving merge conflicts
    - use process to try to avoid merge conflicts, if possible
    - commit early and often
    - pull as often as you can