SECTION 1:
CODE REASONING + VERSION CONTROL

CSE 331 – Summer 2018

slides borrowed and adapted from Alex Mariakis and CSE 390a, CSE 331 lecture slides, and Justin Bare and Deric Pang Section 1 slides.

OUTLINE

- **Introductions**
- **Code Reasoning**
  - **Forward Reasoning**
  - **Backward Reasoning**
  - **Weaker vs. Stronger statements**
- **Version control**

REASONING ABOUT CODE

- **Two purposes**
  - *Prove* our code is correct
  - Understand *why* code is correct
- **Forward reasoning: determine what follows from initial conditions**
- **Backward reasoning: determine sufficient conditions to obtain a certain result**

TERMINOLOGY

- The program state is the values of all the (relevant) variables
- An assertion is a logical formula referring to the program state (e.g., contents of variables) at a given point
- An assertion holds for a program state if the formula is true when those values are substituted for the variables

TERMINOLOGY

- An assertion before the code is a precondition – these represent assumptions about when that code is used
- An assertion after the code is a postcondition – these represent what we want the code to accomplish

FORWARD REASONING

- Given: Precondition
- Finds: postcondition for given precondition.
  - Aka Finds program state after executing code, when using given assumptions of program state before execution.

FORWARD REASONING

```
// {x >= 0, y >= 0}
y = 16;
//
x = x + y
//
x = sqrt(x)
//
y = y - x
//
```

FORWARD REASONING

```
// {x >= 0, y >= 0}
y = 16;
// {x >= 0, y = 16}
x = x + y
//
x = sqrt(x)
//
y = y - x
//
```

FORWARD REASONING

```
// {x >= 0, y >= 0}
y = 16;
// {x >= 0, y = 16}
x = x + y
// {x >= 16, y = 16}
x = sqrt(x)
//
y = y - x
//
```

FORWARD REASONING

```
// {x >= 0, y >= 0}
y = 16;
// {x >= 0, y = 16}
x = x + y
// {x >= 16, y = 16}
x = sqrt(x)
// {x >= 4, y = 16}
y = y - x
//
```

FORWARD REASONING

```
// {x >= 0, y >= 0}
y = 16;
// {x >= 0, y = 16}
x = x + y
// {x >= 16, y = 16}
x = sqrt(x)
// {x >= 4, y = 16}
y = y - x
// {x >= 4, y <= 12}
```

FORWARD REASONING

```
// {true}
if (x>0) {
        //
        abs = x
        //
}
else {
        //
        abs = -x
        //
}
//
//
```

FORWARD REASONING

```
// {true}
if (x>0) {
        // {x > 0}
        abs = x
        //
}
else {
        // {x <= 0}
        abs = -x
        //
}
//
//
```

FORWARD REASONING

```
// {true}
if (x>0) {
        // {x > 0}
        abs = x
        // {x > 0, abs = x}
}
else {
        // {x <= 0}
        abs = -x
        // {x <= 0, abs = -x}
}
//
//
```

FORWARD REASONING

```
// {true}
if (x>0) {
        // {x > 0}
        abs = x
        // {x > 0, abs = x}
}
else {
        // {x <= 0}
        abs = -x
        // {x <= 0, abs = -x}
}
// {x > 0, abs = x OR x <= 0, abs = -x}
//
```

FORWARD REASONING

```
// {true}
if (x>0) {
        // {x > 0}
        abs = x
        // {x > 0, abs = x}
}
else {
        // {x <= 0}
        abs = -x
        // {x <= 0, abs = -x}
}
// {x > 0, abs = x OR x <= 0, abs = -x}
// {abs = |x|}
```

BACKWARD REASONING

- Given: Postcondition
- Finds: The weakest precondition for given postcondition.

BACKWARD REASONING

- Given: Postcondition
- Finds: The weakest precondition for given postcondition.
- So, finds most general assumption code will use to get given postcondition.

BACKWARD REASONING

```
//
a = x + b;
//
c = 2b - 4
//
x = a + c
// {x > 0}
```

BACKWARD REASONING

```
//
a = x + b;
//
c = 2b - 4
// {a + c > 0}
x = a + c
// {x > 0}
```

BACKWARD REASONING

```
//
a = x + b;
// {a + 2b – 4 > 0}
c = 2b - 4
// {a + c > 0}
x = a + c
// {x > 0}
```

BACKWARD REASONING

```
// Backward reasoning is used to determine the
// weakest precondition
// {x + 3b - 4 > 0}
a = x + b;
// {a + 2b – 4 > 0}
c = 2b - 4
// {a + c > 0}
x = a + c
// {x > 0}
```

ASIDE: WEAKEST PRECONDTION?

- What is weakest precondition?
- Well, precondition is just a statement, so…Better ask what makes a statement weaker vs. Stronger?

WEAKER VS. STRONGER

- **Weaker statements = more general**
- **Stronger statements = more specific aka more informational**
- **Stronger statements are more restrictive**
  - Ex: x = 16 is stronger than x > 0
  - Ex: “Alex is an awesome TA” is stronger than “Alex is a TA”
- **If A implies B, A is stronger and B is weaker.**
- **If B implies A, B is stronger and A is weaker.**
- **If neither, then A and B not comparable.**

HOARE TRIPLES

- **Hoare triples are just an extension of logical implication**
  - Hoare triple: {P} S {Q}
  - P = precondition
  - S = single line of code
  - Q = postcondition
- **A Hoare triple can be valid or invalid**
  - Valid if for all states for which P holds, executing S always produces a state for which Q holds
  - Invalid otherwise

HOARE TRIPLE EXAMPLE #1

- *{x != 0} y = x*x; {y > 0}*
- Is this valid?

HOARE TRIPLE EXAMPLE #1

- *{x != 0} y = x*x; {y > 0}*
- Is this valid?

  - Yes

HOARE TRIPLE EXAMPLE #2

- Is {false} S {Q} a valid Hoare triple?

HOARE TRIPLE EXAMPLE #2

- Is {false} S {Q} a valid Hoare triple?
  - Yes. Because P is false, there are no conditions when P holds
  - Therefore, for all states where P holds (i.e. none) executing *S* will produce a state in which *Q* holds

HOARE TRIPLE EXAMPLE #3

- Is {P} S {true} a valid Hoare triple?

HOARE TRIPLE EXAMPLE #3

- Is {P} S {true} a valid Hoare triple?
  - Yes. Any state for which P holds that is followed by the execution of S will produce some state
  - For any state, true always holds (i.e. true is true)

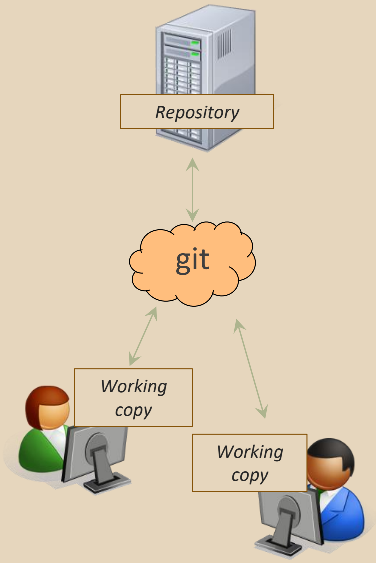
VERSION CONTROL

WHAT IS VERSION CONTROL?

- Also known as source control/revision control
- System for tracking changes to code
  - Software for developing software
- Essential for managing projects
  - See a history of changes
  - Revert back to an older version
  - Merge changes from multiple sources
- We'll be talking about git/GitLab, but there are alternatives
  - Subversion, Mercurial, CVS
  - Email, Dropbox, USB sticks (don't even think of doing this)

VERSION CONTROL ORGANIZATION

- A *repository* stores the master copy of the project
  - Someone creates the repo for a new project
  - Then nobody touches this copy directly
  - Lives on a server everyone can access
- Each person *clones* her own *working copy*
  - Makes a local copy of the repo
  - You'll always work off of this copy
  - The version control system syncs the repo and working copy (with your help)



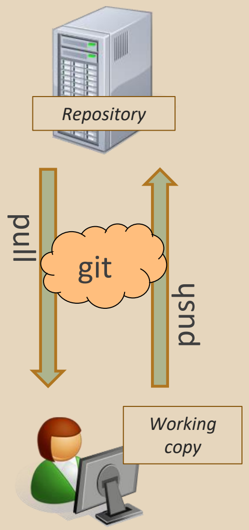
REPOSITORY

- Can create the repository anywhere
  - Can be on the same computer that you're going to work on, which might be ok for a personal project where you just want rollback protection
- But, usually you want the repository to be robust:
  - On a computer that's up and running 24/7
    - Everyone always has access to the project
  - On a computer that has a redundant file system
    - No more worries about that hard disk crash wiping away your project!
- We'll use CSE GitLab – very similar to GitHub but tied to CSE accounts and authentication

VERSION CONTROL COMMON ACTIONS

Most common commands:

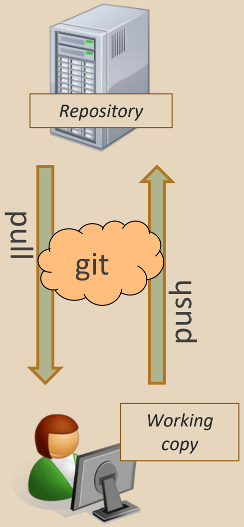
- commit / push
  - integrate changes *from* your working copy *into* the repository
- pull
  - integrate changes *into* your working copy *from* the repository



VERSION CONTROL UPDATING FILES

In a bit more detail:

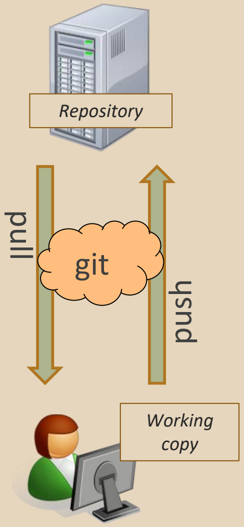
- You make some local changes, test them, etc., then…
- git add – tell git which changed files you want to save in repo
- git commit – save all files you've "add"ed in the local repo copy as an identifiable update
- git push – synchronize with the GitLab repo by pushing local committed changes



VERSION CONTROL COMMON ACTIONS (CONT.)

Other common commands:

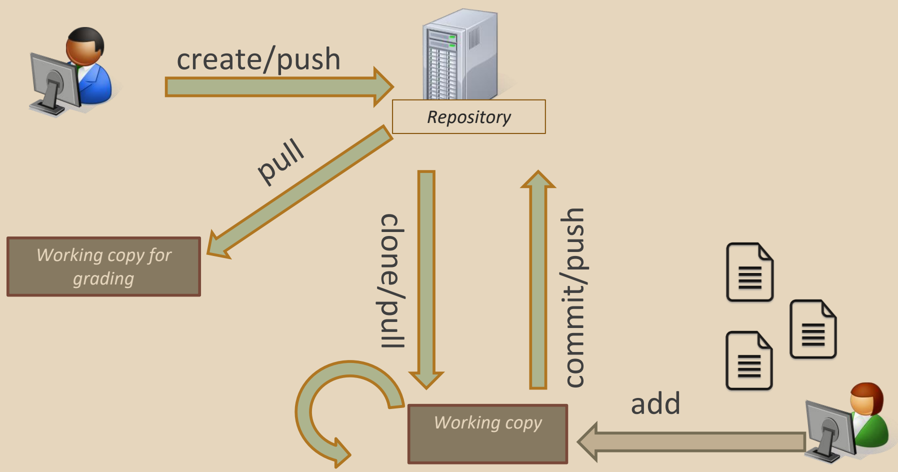
- add, rm
  - add or delete a file in the working copy
  - just putting a new file in your working copy does not add it to the repo!
  - still need to commit to make permanent



THIS QUARTER

- **We distribute starter code by adding it to your GitLab repo. You retrieve it with git clone the first time then git pull for later assignments**
- **You will write code using Eclipse**
- **You turn in your files by adding them to the repo, committing your changes, and eventually pushing accumulated changes to GitLab**
- **You "turn in" an assignment by tagging your repo and pushing the tag to GitLab**
- **You will validate your homework by SSHing onto attu, cloning your repo, and running an Ant build file**

331 VERSION CONTROL



AVOIDING GIT PROBLEMS

- For the projects in this class, you should never have to merge
  - Except when the staff pushes out a new assignment
- Rules of thumb for working in multiple places:
  - Each time before you start working on your assignment, git pull to get the latest code
  - Each time after you are done working for a while, git add/commit/push in order to update the repository with the latest code