Git and GitHub

CS 4411

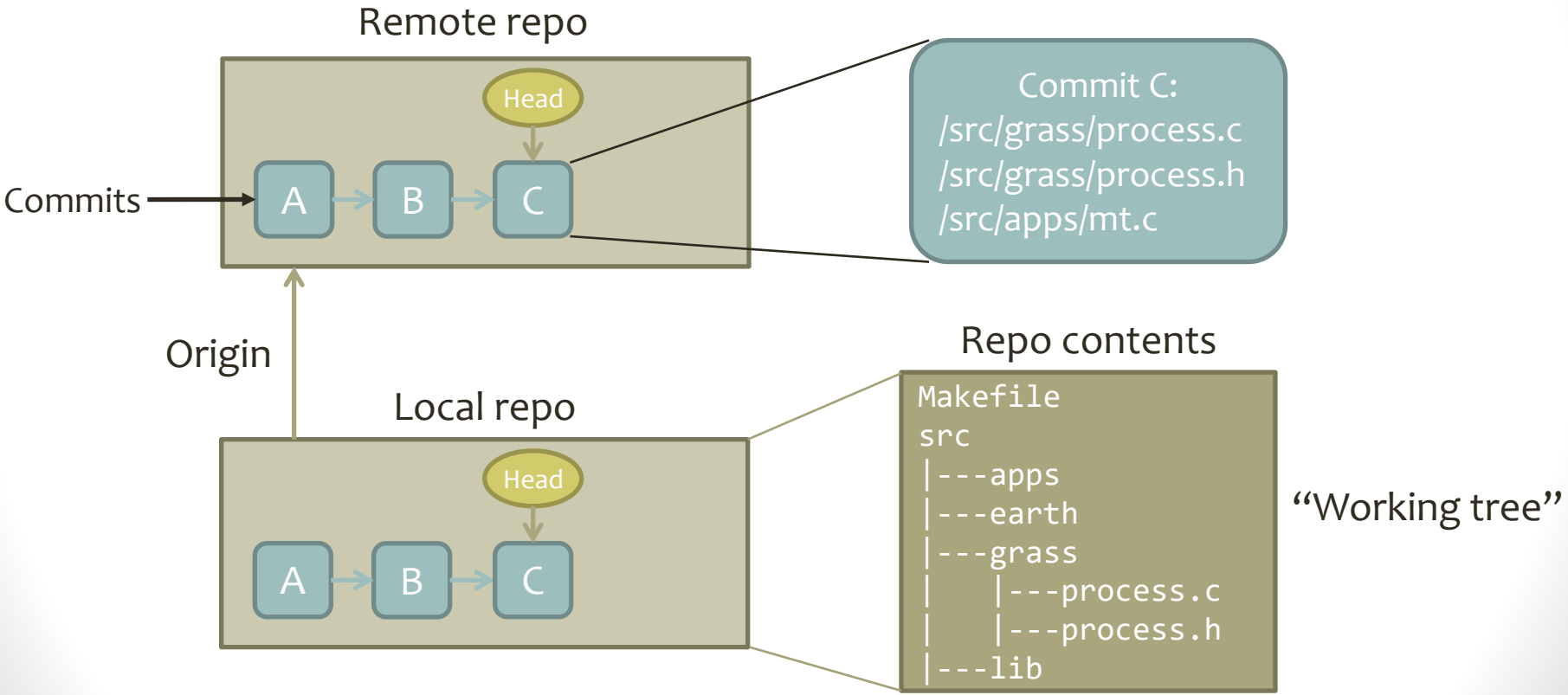
Spring 2020

If that doesn't fix it, git.txt contains the phone number of a friend of mine who understands git. Just wait through a few minutes of "It's really pretty simple, just think of branches as..." and eventually you'll learn the commands that will fix everything.

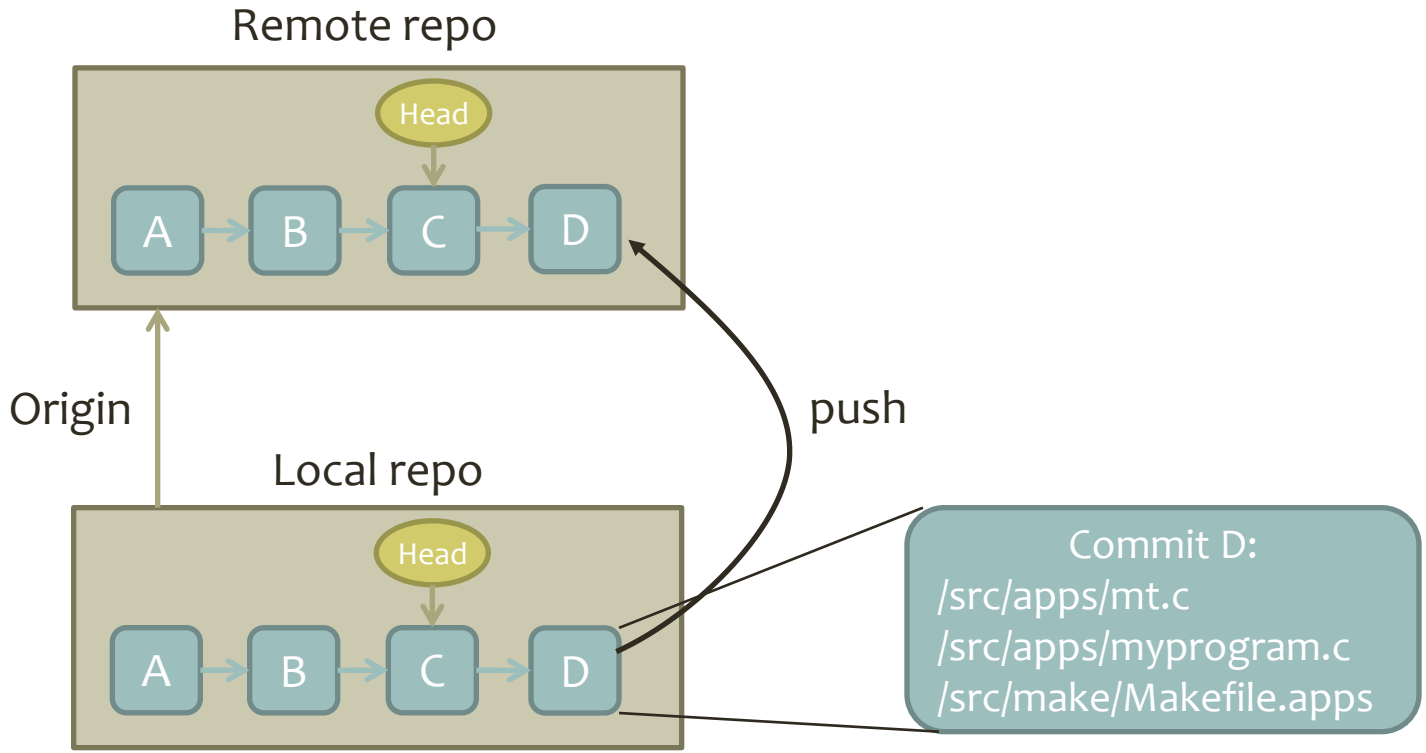
Outline for Today

- Git overview
  - Git vs. GitHub
- Basic Git commands
- Conflicts and merges
- Branches
- Recovering from errors

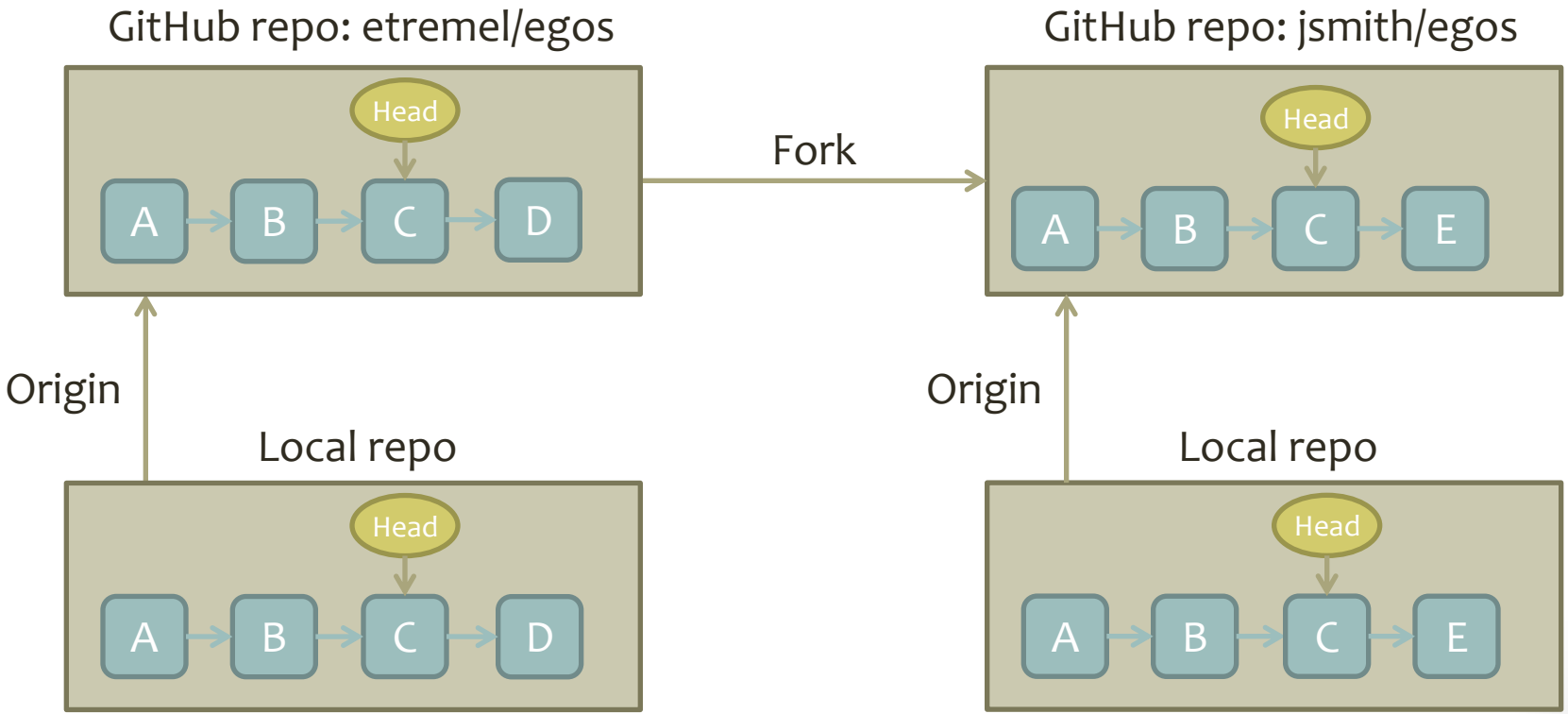
Git Model


Remote repo
Head
Commits
A
B
C
Commit C:
/src/grass/process.c
/src/grass/process.h
/src/apps/mt.c
Origin
Repo contents
Local repo
Head
A
B
C
Makefile
src
|---apps
|---earth
|---grass
| |---process.c
| |---process.h
|---lib
“Working tree”

Making a Commit



Git with GitHub



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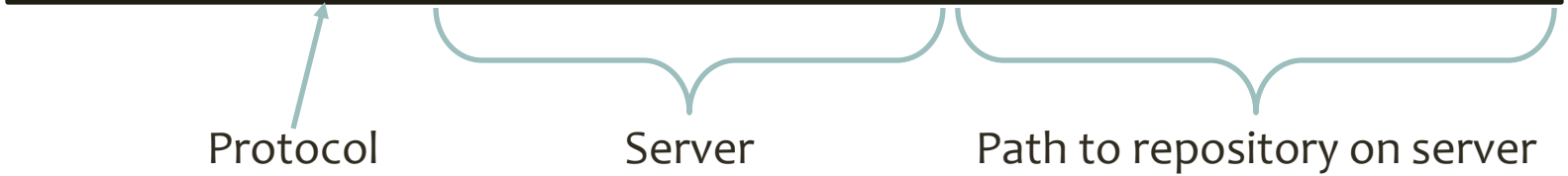
Getting Started with Clone

- git clone: Create a new local repository by copying a remote repo

```
$ git clone https://github.coecis.cornell.edu/cs4411-2020sp/ejt64-egos.git
```



- Result: New folder named "ejt64-egos" in current directory, containing new git repo
  - Contents identical to repo on server
  - **Origin** set to `https://github.coecis.cornell.edu/cs4411-2020sp/ejt64-egos.git`

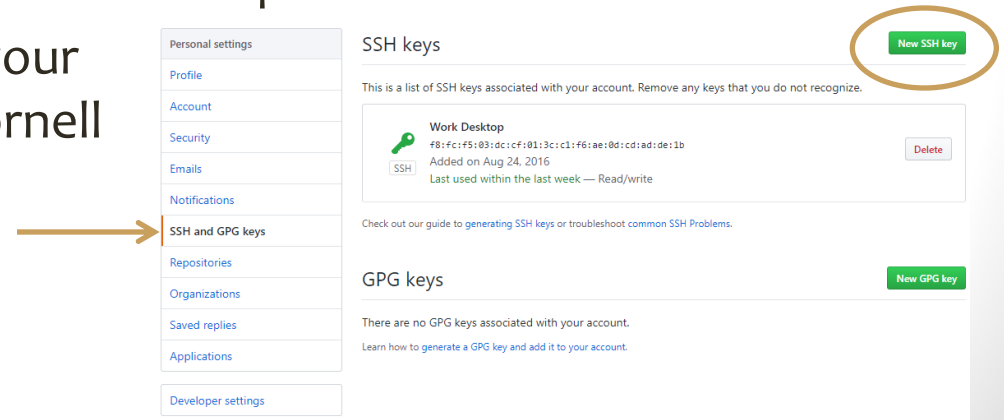
HTTPS or SSH?

```
$ git clone https://github.coecis.cornell.edu/cs4411-2020sp/ejt64-egos.git
```

- Easy to start, no setup required
- Must enter username and password every time you pull or push

```
$ git clone git@github.coecis.cornell.edu:cs4411-2020sp/ejt64-egos.git
```

- Once set up, no username or password required
- Need to create an SSH key on your computer and add it to your Cornell GitHub account



Add and Commit

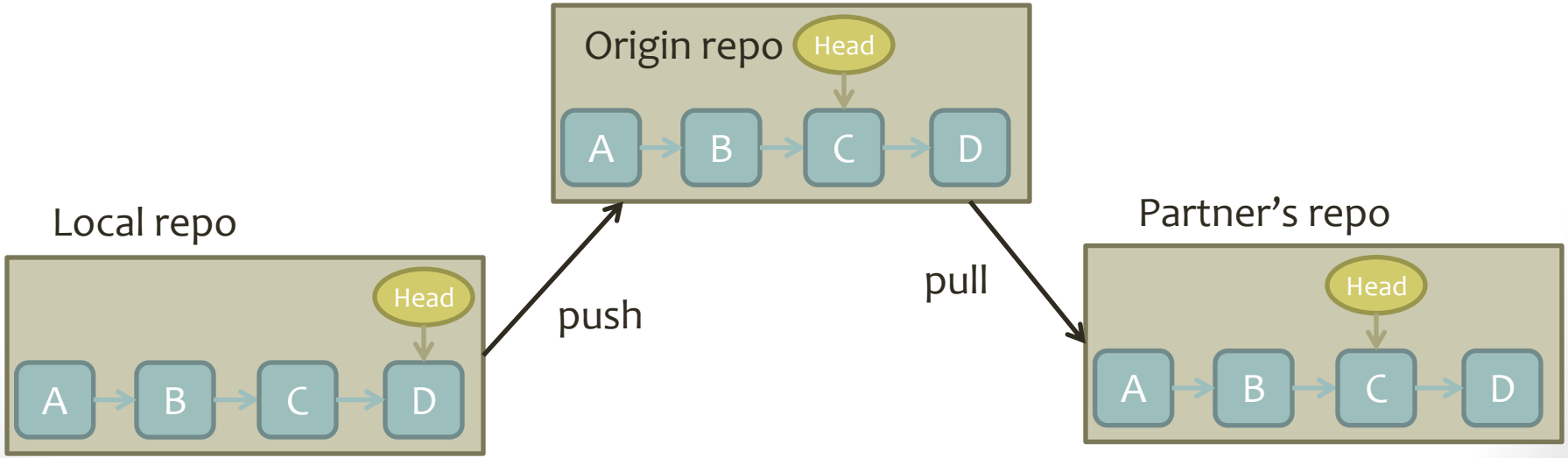
1. Make changes to files
2. Choose some changed files that you're ready to "publish"
3. git add the changed files
4. git commit and write a message

```
~/egos$ vim src/apps/mt.c
~/egos$ vim src/grass/process.c
~/egos$ git add src/apps/mt.c
~/egos$ git commit
```

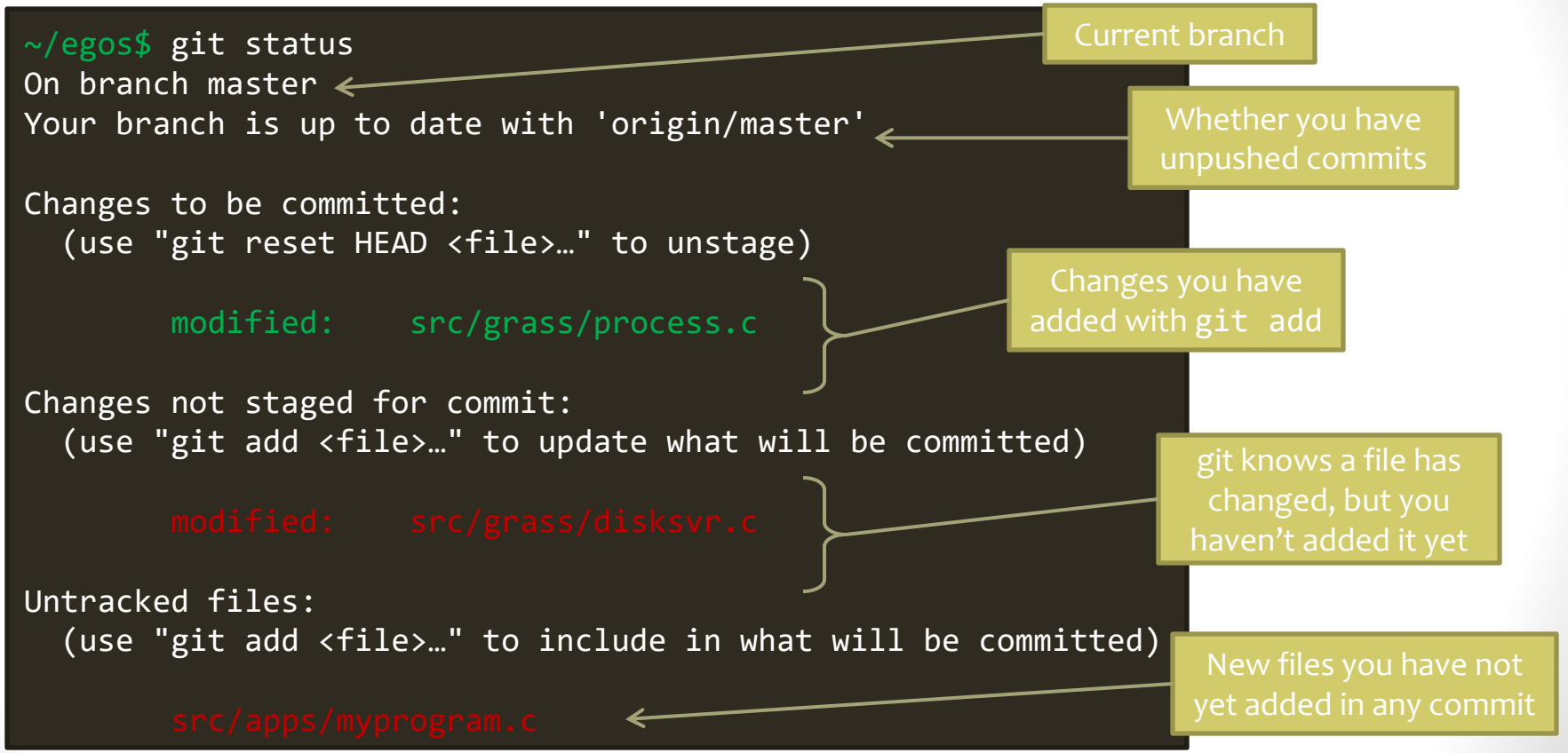
Commit E:
/src/apps/mt.c

Pull and Push

- At first, a commit is only on your local repo
- `git push` copies commits to the "origin" remote repo
- `git pull` downloads commits from origin and applies them



Understanding Git Status



Git Status After a Commit

```
~/egos$ git status
On branch master
Your branch is 1 commit behind 'origin/master'

Changes not staged for commit:
  (use "git add <file>…" to update what will be committed)

        modified:    src/grass/process.c

Untracked files:
  (use "git add <file>…" to include in what will be committed)

        src/apps/tags
        src/grass/tags
```

You made a commit, but haven't pushed

After your last commit, you continued editing this file

These files still haven't been added to any commit

Ignoring Files You'll Never Add

- Some files you never want to commit: ctags files, compiled output, LaTeX aux files…
- Git will keep bothering you about them in `git status`
- Add a file named `.gitignore` to the root of your repo, and then add it to a commit

```
~/egos$ cat .gitignore
# ctags files
tags
# LaTeX junk
*.aux
*.log
*.bbl
# The debug log directory
logs/
# Object files in the build dir
build/**/*.o
~/egos$
```

https://www.atlassian.com/git/tutorials/saving-changes/gitignore

Diff: What Am I Committing?

```
~/egos$ git diff
diff --git a/src/lib/queue.c b/src/lib/queue.c
index c638853..19106c3 100644
--- a/src/lib/queue.c
+++ b/src/lib/queue.c
@@ -19,7 +19,7 @@ struct element {
 void queue_init(struct queue *q){
        q->first = 0;
        q->last = &q->first;
-       q->nelts = 0;
+       q->num_elements = 0;
 }

 /* Put it on the wrong side of the queue.  I.e., make it the next
@@ -34,7 +34,7 @@ void queue_insert(struct queue *q, void *item){
        }
        e->next = q->first;
        q->first = e;
```

First file with changes

Line number skipped to

Deleted from original (last commit)

Added in current state of file

Skip ahead again to line 34

Diff Details

```
~/egos$ git diff src/grass/process.c
```

- Shows differences only for that file

```
~/egos$ git diff
~/egos$
```

- Why does it give no results? I know I made changes!
- Answer: you have already `git add`ed your changes

```
~/egos$ git diff --staged
diff --git a/src/lib/queue.c b/src/lib/queue.c
index c638853..19106c3 100644
--- a/src/lib/queue.c
+++ b/src/lib/queue.c
@@ -19,7 +19,7 @@ struct element {
```

Un-Adding and Deleting

- Oops, I didn't mean to add that file!

```
~/egos$ git add src/lib/queue.c
~/egos$ git reset HEAD src/lib/queue.c
```

- Telling git you want to delete myprogram.c:

```
~/egos$ git rm src/apps/myprogram.c
~/egos$ git status
On branch master
Your branch is up to date with 'origin/master'

Changes to be committed:
  (use "git reset HEAD <file>…" to unstage)

        deleted:    src/apps/myprogram.c
```

Renaming

- Telling git you want to rename myprogram.c:

```
~/egos$ git mv src/apps/myprogram.c src/apps/newname.c
~/egos$ git status
On branch master
Your branch is up to date with 'origin/master'

Changes to be committed:
  (use "git reset HEAD <file>…" to unstage)

        renamed:    src/apps/myprogram.c -> src/apps/newname.c
```

- Otherwise, git will think you deleted myprogram.c, and both myprogram.c and newname.c will end up in the repo

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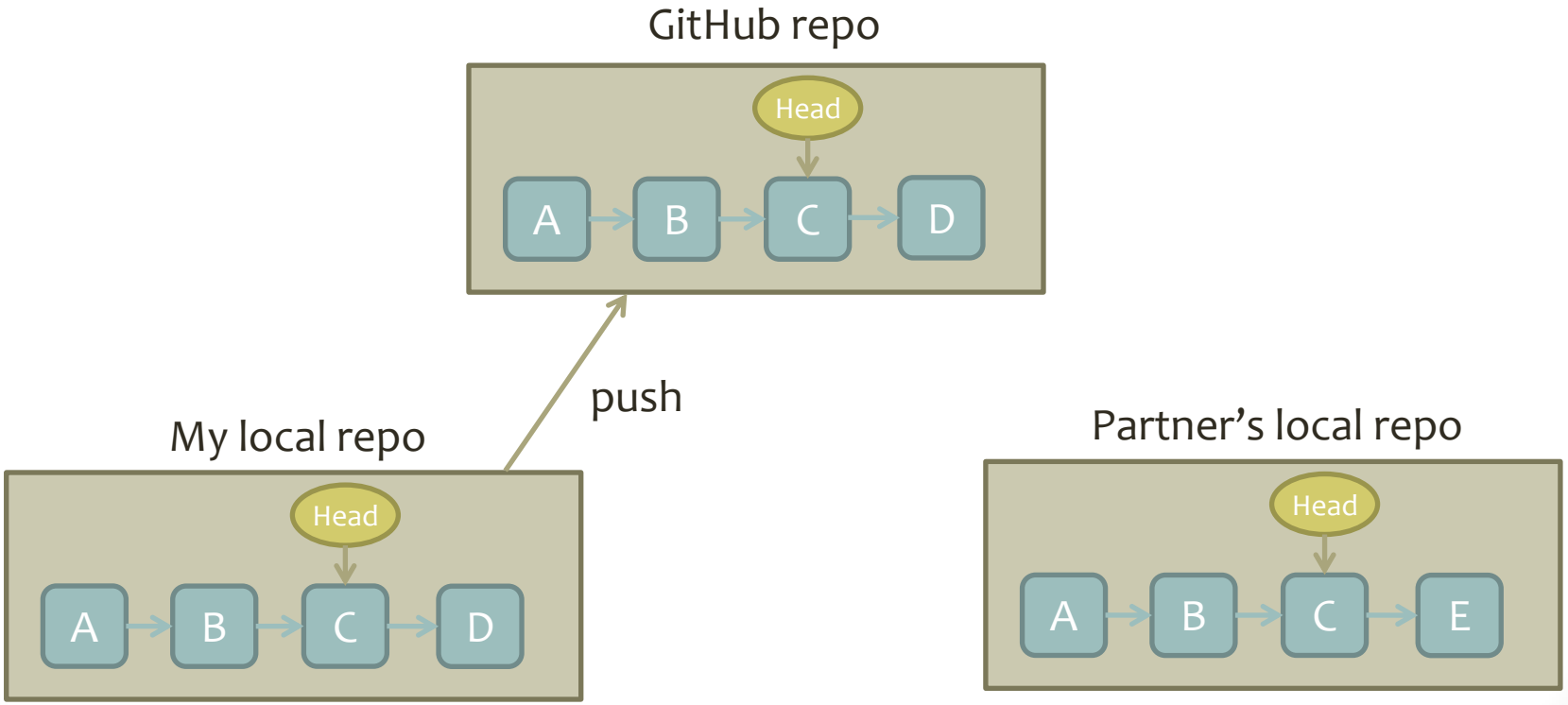
Concurrent Changes



Possible Outcomes

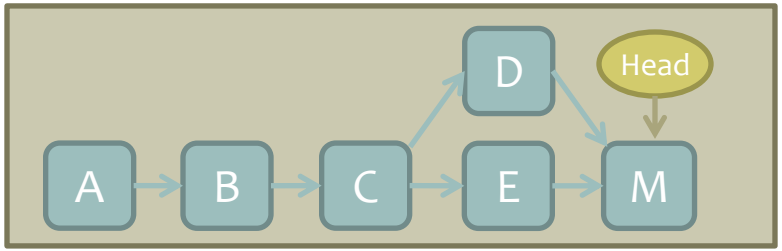
- No conflicts, just merge

```
~/egos$ git pull
# Editor pops up
Merge made by the 'recursive' strategy
  src/lib/queue.c
  1 file changed,
```

```
Merge branch 'master' of https://github.coecis.cornell.edu/etremel/egos.git

# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit
```

Partner's local repo



Possible Outcomes

- Conflicting changes to the same file(s)

```
~/egos$ git pull
Auto-merging src/lib/queue.c
CONFLICT (content): Merge conflict in src/lib/queue.c
Automatic merge failed; fix conflicts and then commit the result
~/egos$ git status
On branch master
Your branch and 'origin/master' have diverged,
and have 1 and 1 different commits each, respectively.
…
Unmerged paths:
  (use "git add <file>..." to mark resolution)

        both modified:   src/lib/queue.c
```

Conflict File Syntax

Inside queue.c:

```
void queue_add(struct queue *queue, void *item){
        struct element *e = calloc(1, sizeof(*e));

        e->item = item;
        e->next = 0;
<<<<<<< HEAD
        *queue->last = e;
        queue->last = &e->next;
        queue->nelts++;
=======
        *q->last = e;
        q->last = &e->next;
        q->num_elements++;
>>>>>>> 354a72479204de581ffa83551843b92e585506b8
}
```

Merged lines with no conflicts

HEAD means these changes are in your local HEAD commit

Your local version of conflicting lines

Origin repo's version of conflicting lines

Hash of commit from origin that contains these conflicting changes

Finishing the Merge

- Edit the file to choose a single version of the conflicting lines
- Make sure to delete the `<<<<<<<` and `=======` lines!
- When you have resolved the conflict:

```
~/egos$ git add src/lib/queue.c
~/egos$ git commit
# Write a message for the merge commit
~/egos$ git push
```

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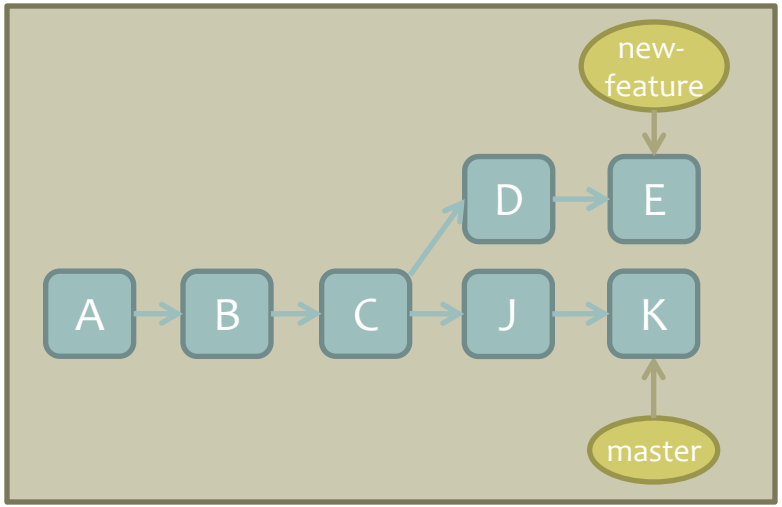
Git Branches

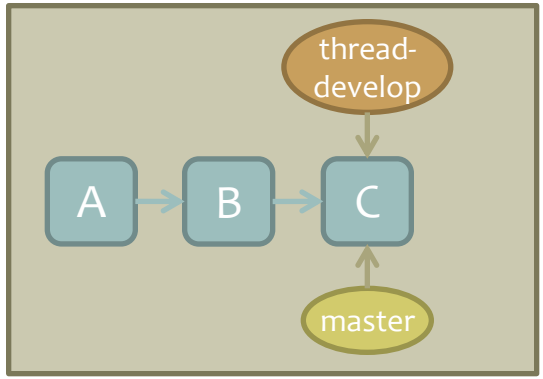
- Track different sequences of commits diverging from common starting point
- Make explicit what happened already when you & your partner made conflicting commits
- Let you choose when to merge



Branch Basics

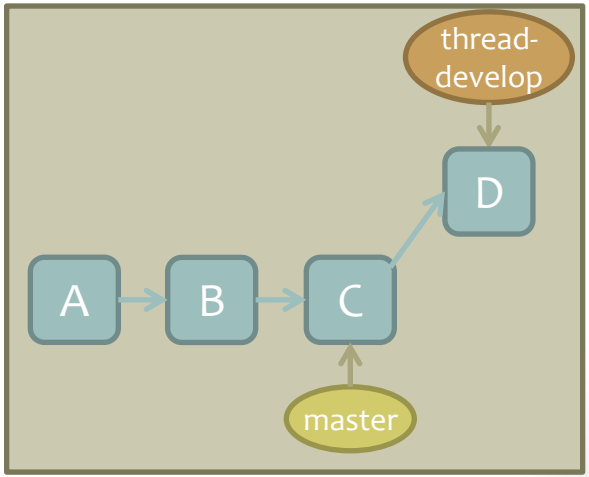
```
~/egos$ git checkout -b thread-develop
Switched to a new branch 'thread-develop'
```

- Creates a new branch, pointing to same commit as master




```
~/egos$ git add src/apps/mt.c
~/egos$ git commit
```

- New commit goes on thread-develop, master still points to last commit



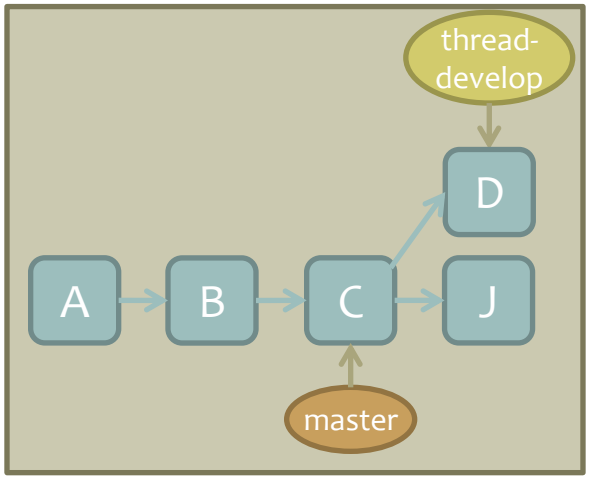
Branch Basics

```
~/egos$ git checkout master
Switched to branch 'master'
Your branch is up to date with 'origin/master'
```

- Changes your repo's active branch to master – you'll notice the changes you made to `mt.c` are gone

```
~/egos$ git add src/grass/process.c
~/egos$ git commit
```

- This commit goes on master, and the HEAD pointer for master moves up



Pushing and Pulling

- You want to push the commit on your new branch to GitHub:

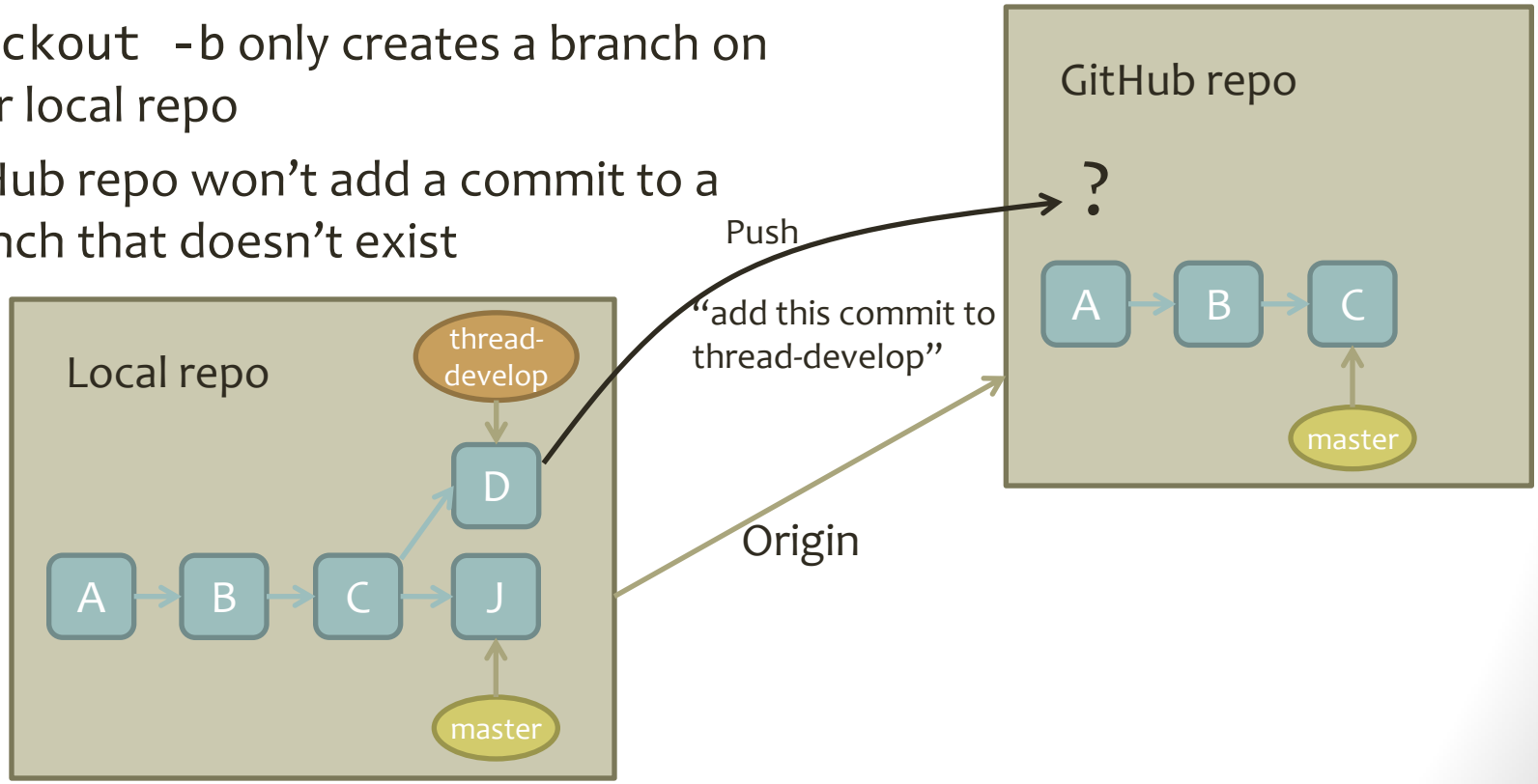
```
~/egos$ git checkout thread-develop
Switched to branch 'thread-develop'
~/egos$ git push
fatal: The current branch thread-develop has no upstream branch.
To push the current branch and set the remote as upstream, use

    git push --set-upstream origin thread-develop
```

- OK, do what it says
- After this point, `git push` will just work

Why Was That Necessary?

- `checkout -b` only creates a branch on your local repo
- GitHub repo won't add a commit to a branch that doesn't exist



Pushing and Pulling

- You want to switch to a new branch your partner created

```
~/egos$ git checkout thread-develop
error: pathspec 'thread-develop' did not match any file(s) known to git
```

- Why didn't that work?

```
~/egos$ git pull
Remote: Enumerating objects
…
From github.coecis.cornell.edu:etremel/egos
 * [new branch]      thread-develop -> origin/thread-develop
Already up to date.
~/egos$ git checkout thread-develop
Branch 'thread-develop' set up to track remote branch 'thread-develop' from 'origin'
Switched to a new branch 'thread-develop'
```

Now the local repo knows about the branch

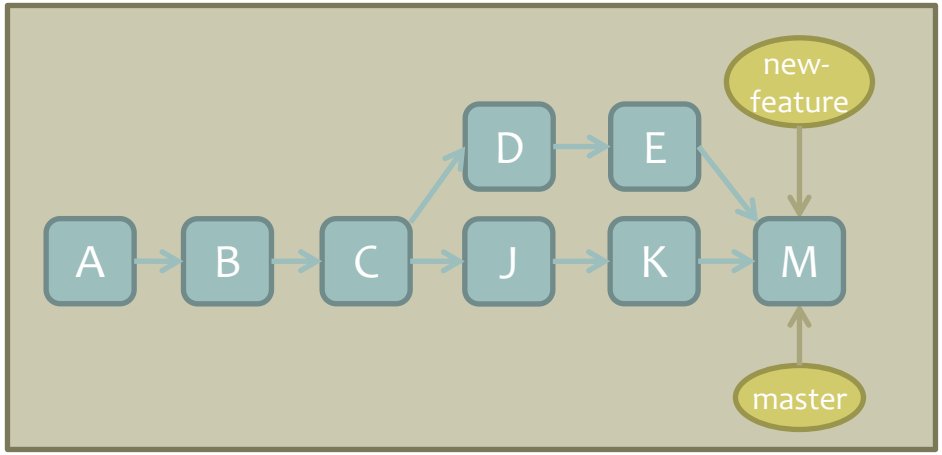
Merging Branches

- Eventually, you'll want to merge your branch back into master
- First, switch your current branch to **master**

```
~/egos$ git pull
~/egos$ git checkout master
```

- Then, merge the feature branch **into** master

```
~/egos$ git merge new-feature
~/egos$ git push
```

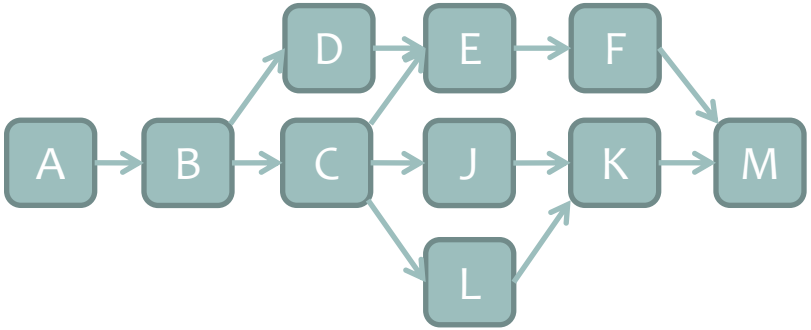


Resolve any merge conflicts, same as when you pull and see conflicts

Publish the merge commit, so everyone else can see the merge

Repository Design with Branches

- In many software teams, **master** is the "stable" branch
- Each new feature or bug fix is developed on its own branch
- When tested and safe, branch is merged into master
- While developing on a branch, merge **from** master **into** your branch to get updates and bugfixes



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Some Useful Incantations

- Oops! I made a commit but then made one small change

```
# Do this BEFORE you push
$ git add changed-file.c
$ git commit --amend --no-edit
```

- Oops! I want to edit the message on the commit I just made

```
$ git commit --amend
# Edit the message in your editor
```

- Oops! I deleted a file and didn't mean to

```
$ git checkout path/to/file.c
```

Branch-Related Problems

- I just made a commit to master, but I should have put it on a new branch instead

```
# Create a new branch with the same state as master
$ git branch new-branch-name
# Remove the latest commit from master
$ git reset HEAD~ --hard
# Switch to the new branch, which still has the commit
$ git checkout new-branch-name
```

Branch-Related Problems

- I just committed to the wrong branch – I thought I was on the `queue-develop` branch but I'm on the `experiments` branch

```
# Undo the last commit, but leave files changed
$ git reset HEAD~ --soft
# Stash the changed files, then move to the right branch
$ git stash
$ git checkout queue-develop
$ git stash pop
# Commit the changes on the correct branch
$ git add queue.c queue.h
$ git commit
```

The Unnecessary Merge

- Make changes, commit, push… then realize your repo is stale

```
$ git push
 ! [rejected]        master -> master (fetch first)
    error: failed to push some refs to 'https://github.com/etremel/egos.git'
    hint: Updates were rejected because the remote contains work that you do
    hint: not have locally. This is usually caused by another repository pushing
    hint: to the same ref. You may want to first integrate the remote changes
    hint: (e.g., 'git pull ...') before pushing again.
```

- Upon pull, you're prompted to create a merge commit

```
$ git pull
```

```
Merge branch 'master' of https://github.com/etremel/egos.git

# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit
```

The Unnecessary Merge

- If I had known to pull first, I wouldn't have to merge!
- First, ensure the merge aborts without making a merge commit
  - Either due to genuine conflict, or by deleting the merge commit message and saving (empty commit message aborts the commit)
- Then:

```
$ git reset --hard
$ git reset HEAD^
$ git stash
$ git pull # no merge this time
$ git stash pop
$ git add foo.c bar.c # etc
$ git commit
```

Discard changes made by merge

Undo your last commit, leaving files changed

Stash your changes, then pull again

Re-do your commit on the new head

Further Reading

- Atlassian Git Tutorials: https://www.atlassian.com/git/tutorials
- Detailed documentation on every command: https://git-scm.com/docs
- Happy Git with R's "Useful Git Patterns:" https://happygitwithr.com/workflows-intro.html
- Oh Shit, Git!?! (source of my error-recovery examples): https://ohshitgit.com/