Git 101: A Crash Course for Productive `git` Usage

for the University of Maryland Cybersecurity Club

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Agenda

1. What is Git?
2. Why should I care?
3. How do I use `git`?
4. Some `git` best practices

Some quick background

Prior to 2005, the Linux kernel used BitKeeper for source control management ("SCM").

In 2005, Andrew Tridgell (of Samba and `rsync` fame) reverse engineered parts of BitKeeper's (proprietary) protocol, causing BitKeeper to withdraw free use of their SCM.*

Git was (initially) hacked together as a replacement, with some features tailored to the Linux community:

- Decentralized, unlike CVS or SVN (which both use a client-server model)
- Performant, even on extremely large source trees ("patching should take no more than 3 seconds")
- Resistant to accidental or intentional corruption

These characteristics, plus its adoption by sites like GitHub and Bitbucket, have made Git the dominant SCM.

* The actual story is longer, and more interesting.

What does Git actually do?

Git is a "distributed version control system", which means very little.

For our purposes, Git:

- Manages source code by breaking it into discrete groups of changes ("commits")
- Manages commits by breaking them into discrete groups ("branches")
- Manages branches by associating them with different copies of the source code ("remotes" and "clones")

There are many ways to interact with Git (like `gitk` and the GitHub website), but we'll use the reference `git` CLI for this presentation. At the end of the day, each has its place and use cases.

Why should I care?

- An increasingly large amount of open source development is done on GitHub and similar platforms, and employers *love* to see open source contributions.
  - Contributions make the most impact when they're delivered well:
    - Clear, concise commit messages
    - Discrete changes broken across different commits
    - Descriptive branch names, &c
- Even if you don't like open source (which is fine), there's a good chance your future employer is using Git. You'll be expected to be comfortable with using Git (or a very similar SCM) on a daily basis.
- Lots of interesting incidental topics: file diffing, conflict resolution (not the HR kind), proper project planning, &c.

Terminology gloss

- Repository - A directory managed by Git
- Working tree - The current state of the repository
- Commit - A discrete set of changes to the repository
- Branch - A labeled collection of changes to the repository
- Remote - A remote copy of the repository

How do I use `git`?

First, you'll have to have it installed. You can install it and follow along with these slides by interacting with a local repository, if you'd like.

To get started, let's copy ("clone") a repository:

```
$ git clone https://github.com/UMD-CSEC/git-101
$ # go into the directory we just cloned
$ cd git-101
```

If we weren't cloning an extant repository, we'd use `mkdir` and `git init` to create a new one:

```
$ mkdir my-repo
$ cd my-repo
$ git init # creates a new repository inside "my-repo"
```

Adding, removing, and modifying files

We now have a local copy of the repository, which we can edit as we please.

Doing so modifies the *working tree*, which is the collection of changes that haven't been made permanent via a *commit*.

To commit a set of changes, we `git add` the files we want and then use `git commit` to compose a message:

```
$ git add README.md
$ git commit # opens up your editor!
```

Note that `git add` are just used to mark a file for staging – you can also `git add` a file that's just been deleted, in order to commit the deletion.

We'll go into best practices for adding and committing in a bit.

Pushing

When we made the commit on the last slide, we actually did it on a *branch*, which is a linked list of *commit objects* that contains the complete history of changes to the repository. Since we didn't do anything special when running `git commit`, the commit was made to the `master` branch (which is the default branch created by Git).

However, we don't want to keep our changes local – we want to *push* them to a *remote* copy of the repository that we control. This adds redundancy and makes our changes accessible to others.

We do this via `git push`:

```
$ git push origin master
```

Which means "push the `master` branch to the remote repository named `origin`."

Branches and remotes

The pushing example introduced a particular branch (`master`) and a particular remote (`origin`), but it's worth noting that a Git repository can have many branches and many remotes.

Some common branch names:

- `devel` or `unstable` - Often used as a working branch instead of `master`, to indicate the untested or unaudited code within.
- Version numbers - `git tag` can mark the current commit with a number that behaves like a branch, e.g. `v1.0`.

Some common remotes:

- `upstream` - Used to fetch changes from a canonical "upstream" source, like the main developers of a project.
- Other clone names - Used to fetch another user's changes to the same project, for testing or merging into your own work.

Branches and remotes, cont.

This is Git 101, so the `master` branch and the `origin` remote will be your biggest friends.

However, sometimes it's nice to create a new branch to work in:

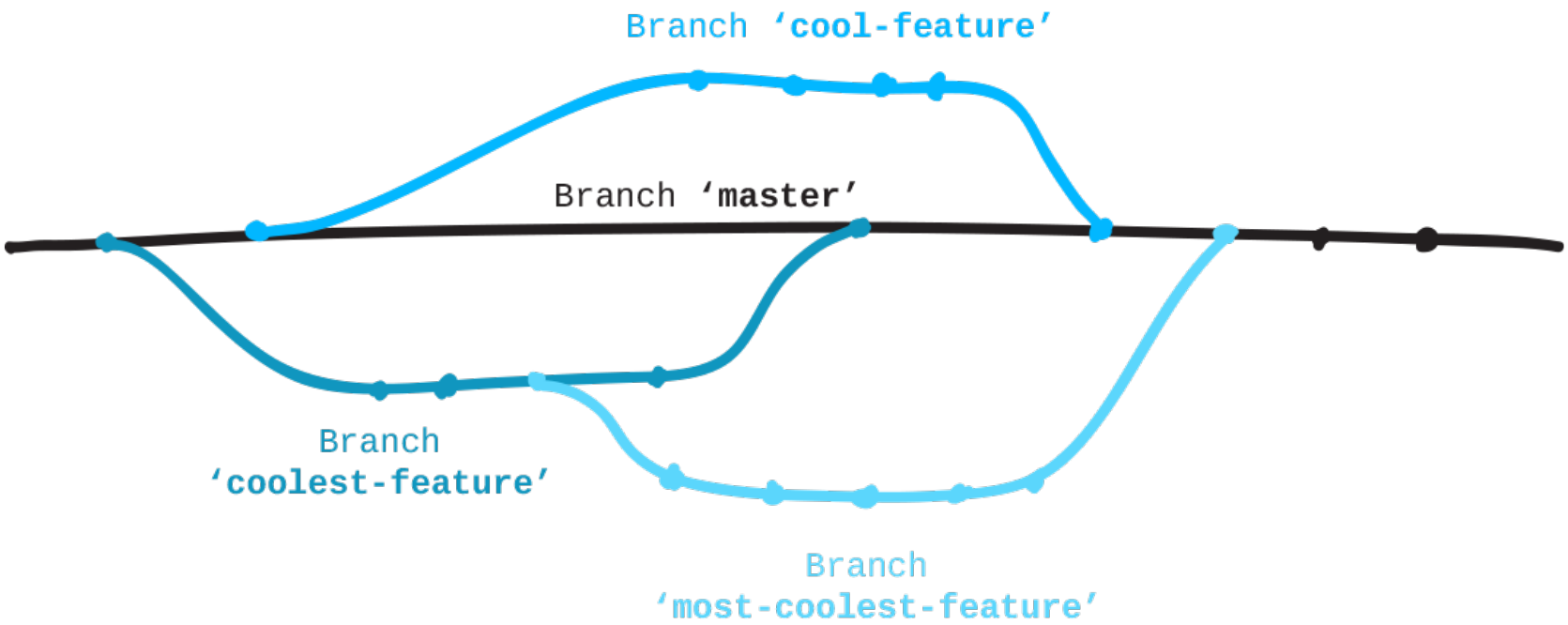
```
$ git checkout -b new-branch
$ # make some changes
$ git add <files>; git commit
```

We can then choose to merge `new-branch` back into `master` (or another branch), or to `git push` it up to one of our remotes:

```
$ git checkout master # go back to master
$ git merge new-branch # merge 'new-branch' into master
$ # OR:
$ git push origin new-branch
```

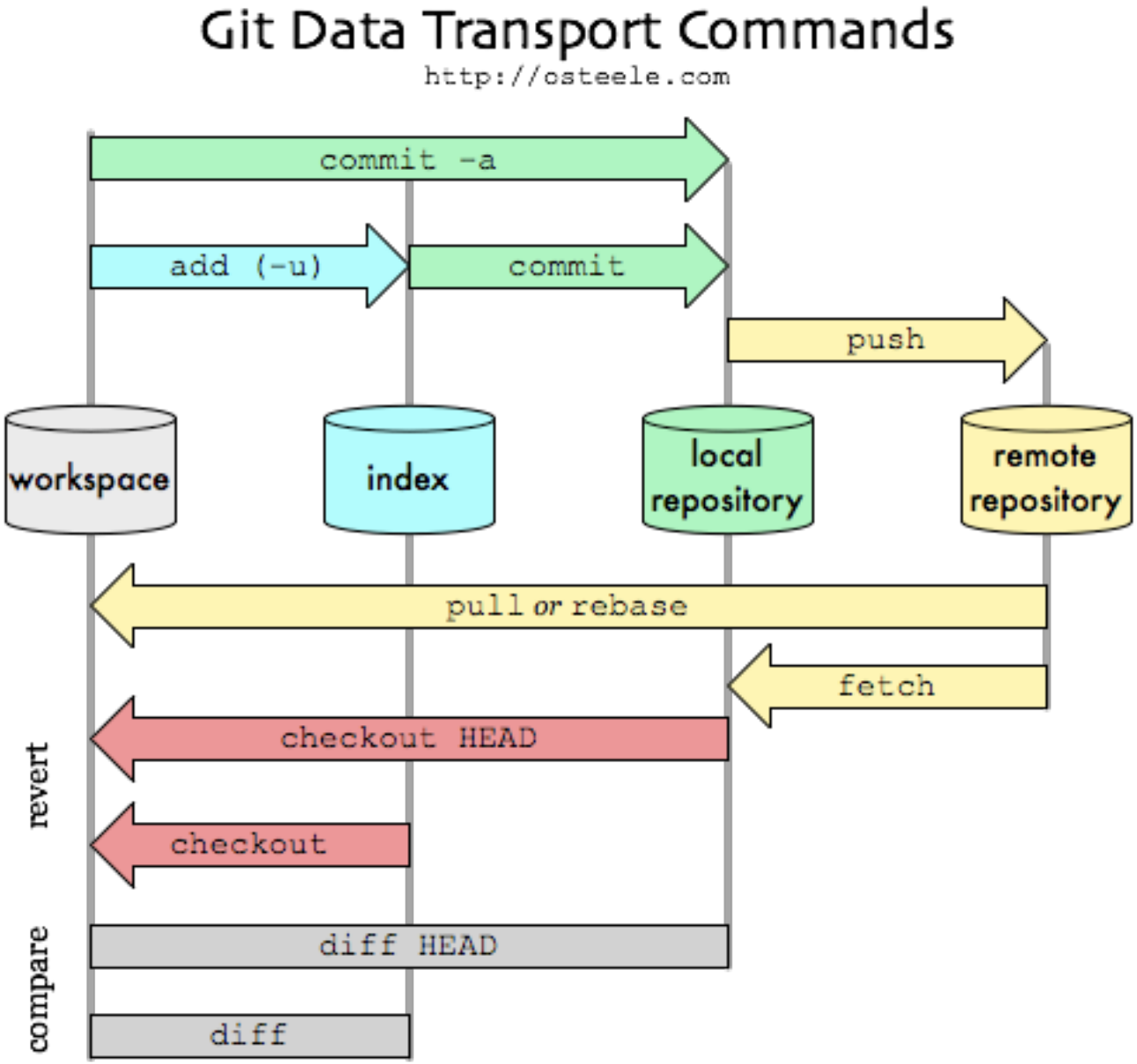
Pushing a new branch up to your `origin` is the most common way to start a Pull Request on GitHub!

Branching, visualized



(Credit: GitHub)

The whole picture



(Credit: Oliver Steele)

A quick recap

99% of your daily Git usage will look something like this:

```
$ git add <filespec>
$ git commit
$ git push <remote> <branch>
```

The other 1% will be managing your remotes and branches:

```
$ git remote add <remote-name> <url>
$ git remote remove <remote-name>
$ git merge <source-branch>
$ git rebase <source-branch>
```

Each of the commands above could take up their own slide, and we'll go over them in detail in Git 102*. In the meantime, the manual pages are your friend!

* If requested by the CSEC overlords.

Some `git` best practices

Now that we know the basics of using `git`, it's important to learn some best practices:

- Descriptive `git commit` messages
- "Semantic" commits
- Branch naming and usage

Best practices - `git commit` messages

The average GitHub project's commit history looks something like this:

```
fix 1
2nd fix
x
stupid bug
added foo
```

This is usually caused by laziness, and *abusing* `git commit -m` (which allows you to commit without opening your editor).

The problems: inconsistent formatting and lack of detail.

`git commit` messages cont.

A *good* `git commit` message looks something like this:

```
component: Short description

Component now does a, b, and c instead of
x, y, and z. Component now understands HTTPS.
```

Observe:

- The first line designates the component being changed, and is under 50 characters.
- A blank line separates the first line from the rest of the message.
- The body of the message uses the imperative mood, and each line is under 70 characters.
- `component` is whatever you're changing (e.g., `api` or `docs`).
- Using Markdown in the message is good!

Semantic commits

In addition to descriptive commit messages, it's good to commit your changes *semantically*.

That means that mutually dependent changes should be committed together (even if they're in different files/parts of the project), and that unrelated changes should get their own commit(s).

Examples:

- API change and documentation change – commit together
  - Reason: The documentation reflects the API, and should be in sync with it.
- Feature addition and version bump – commit separately
  - Reason: Version bumps are a separate activity, and deserve their own commits.
- Bug fix and new test case – commit together
  - Reason: The bug fix is verified by the new test case.

Branch naming and usage

Branch names, like `git commit` messages, should also be descriptive (but much briefer).

`branch-27` means nothing and is hard to remember if you have 500 branches, while `new-https-module` gives you an idea of what's in the branch ("a new HTTPS module") and is easier to remember.

Working on the `master` branch is okay for personal projects and small changes, but you should be using separate branches for larger changes!

Questions?

Miscellanea

The presentation slides are available on GitHub:

- `https://github.com/UMD-CSEC/git-101`

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