Git Workflows

Greg Watson (he/him)
Oak Ridge National Laboratory

Better Scientific Software tutorial @ ISC 2022

Contributors: Patricia Grubel (LANL), Rinku K. Gupta (ANL), Jared O'Neal (ANL), James M. Willenbring (SNL)

LA-UR-21-29292

License, Citation and Acknowledgements

License and Citation

- **The requested citation the overall tutorial is: Anshu Dubey and Gregory R. Watson, Better Scientific Software Tutorial, in ISC High Performance, 2022, Hamburg Germany. DOI: 10.6084/m9.figshare.19781752**
- Individual modules may be cited as *Speaker, Module Title*, in Better Scientific Software tutorial, ISC, 2022 …

Acknowledgements

- This work was supported by the U.S. Department of Energy Office of Science, Office of Advanced Scientific Computing Research (ASCR), and by the Exascale Computing Project (17-SC-20-SC), a collaborative effort of the U.S. Department of Energy Office of Science and the National Nuclear Security Administration.
- This work was performed in part at the Argonne National Laboratory, which is managed by UChicago Argonne, LLC for the U.S. Department of Energy under Contract No. DE-AC02-06CH11357.
- This work was performed in part at the Oak Ridge National Laboratory, which is managed by UT-Battelle, LLC for the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.
- This work was performed in part at the Lawrence Livermore National Laboratory, which is managed by Lawrence Livermore National Security, LLC for the U.S. Department of Energy under Contract No. DE-AC52-07NA27344.
- This work was performed in part at the Los Alamos National Laboratory, which is managed by Triad National Security, LLC for the U.S. Department of Energy under Contract No.89233218CNA000001
- This work was performed in part at Sandia National Laboratories. Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

IDEAS productivity

ECP EXASCALE COMPUTING PROJECT

Content

- Goal using Version Control with Git
- Workflow Mechanisms for Collaboration
  - Branches
  - Cloning
  - Pull Requests
  - Forks
- Code Review
- Exposure to workflows of different complexity
- Collaboration using Git Workflows for CSE projects
- What to think about when evaluating different workflows

Introduction

- Version control (or revision control) is a means of tracking changes made to source code
- Older style is known as a *centralized* version control system
  - One master copy of the repository that everyone accesses
  - E.g. CVS, Subversion, etc.
- Most projects now uses a *distributed* version control system
  - Each developer maintains their own copy of the entire repository
  - E.g. Git, Mercurial, etc.
- Various *hosting services* are available to provide additional functionality, such as collaboration, DevOps, issue tracking, etc.
  - GitHub, GitLab, Bitbucket, etc.

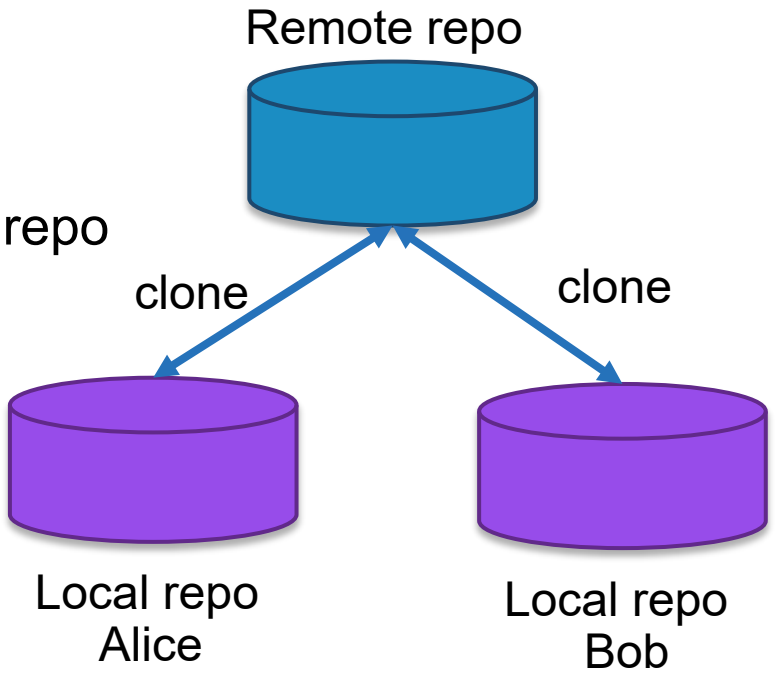
Goal

Development teams would like to use version control to collaborate productively and ensure correct code.

First Workflow

The simplest way of using Git is to mimic the centralized approach

- Called the **Centralized Workflow**
  - See Atlassian/BitBucket for more information
- Leverages local vs. remote repo dimension
  - Integration in local repo when local repos interact with remote repo
  - Working directly on the main branch
- Issues
  - What if you have many team members?
  - What if developers only push once a month?
    - Lengthy development efforts without integrating
    - Occasional contributors
  - What if team members works on different parts of the code?



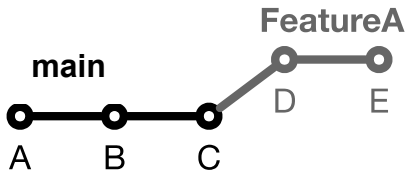
Workflow Mechanisms for Collaboration

- Branches
  - Enable separate development for features or fixes on the same repo
  - Enables different types of Workflows
- Clones
  - Makes a copy of the repository with a pointer back to the original repo
  - May include all branches, or only some
  - Changes can be “pushed” back to the original repo
- Hosted services provide
  - Pull/Merge Requests
    - Enables code review and testing before merge
  - Forks (GitHub)
    - Enables contributions from external collaborators that have read access only
    - Controls on original repo remains with the team

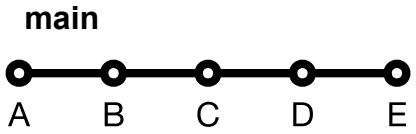
Branches

Branches are independent lines of development

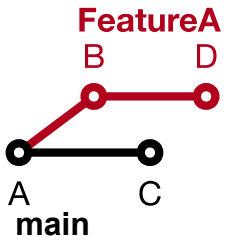
- Use branches to protect main branch
- Feature branches
  - Organize a new feature as a sequence of related commits in a branch
- Branches are usually combined or **merged**
- Develop on a branch, test on the branch, and merge into main
- Integration occurs at merge commits



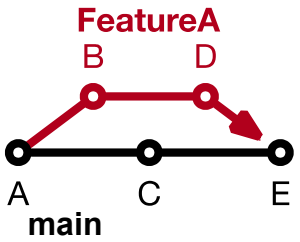
Fast-Forward



No Merge



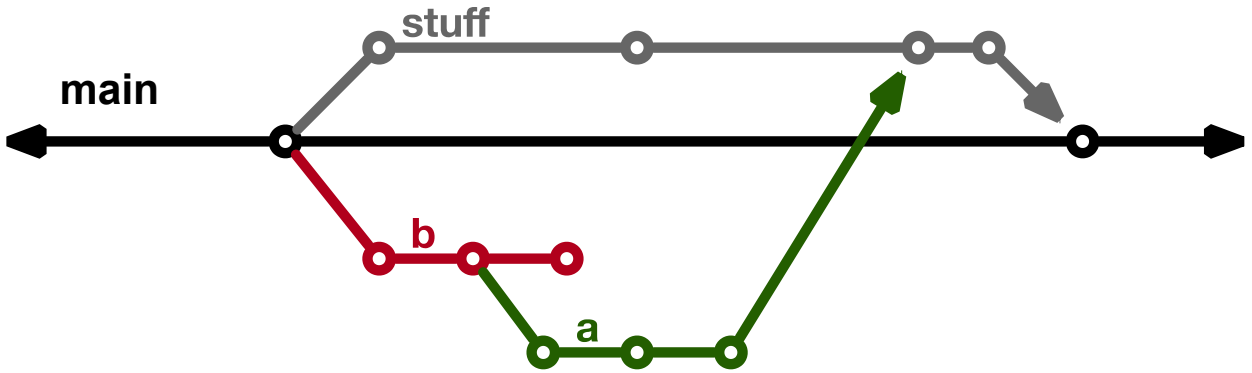
Divergence



Merge Commit

Control Project Branch Complexity

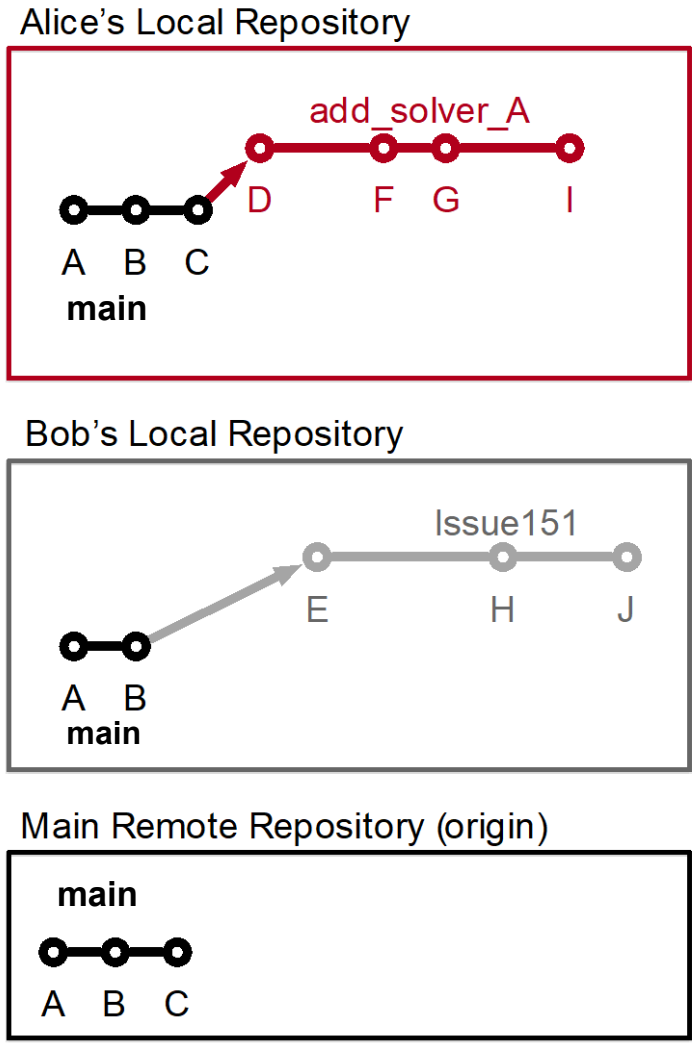
- Workflow policy is needed
  - Project supported branches and workflows should not be unnecessarily complex
  - Individuals and sub-teams can leverage more complex models when advantageous
  - Descriptive names or linked to issue tracking system
  - Where do branches start and end?



Feature Branches

Extend Centralized Workflow

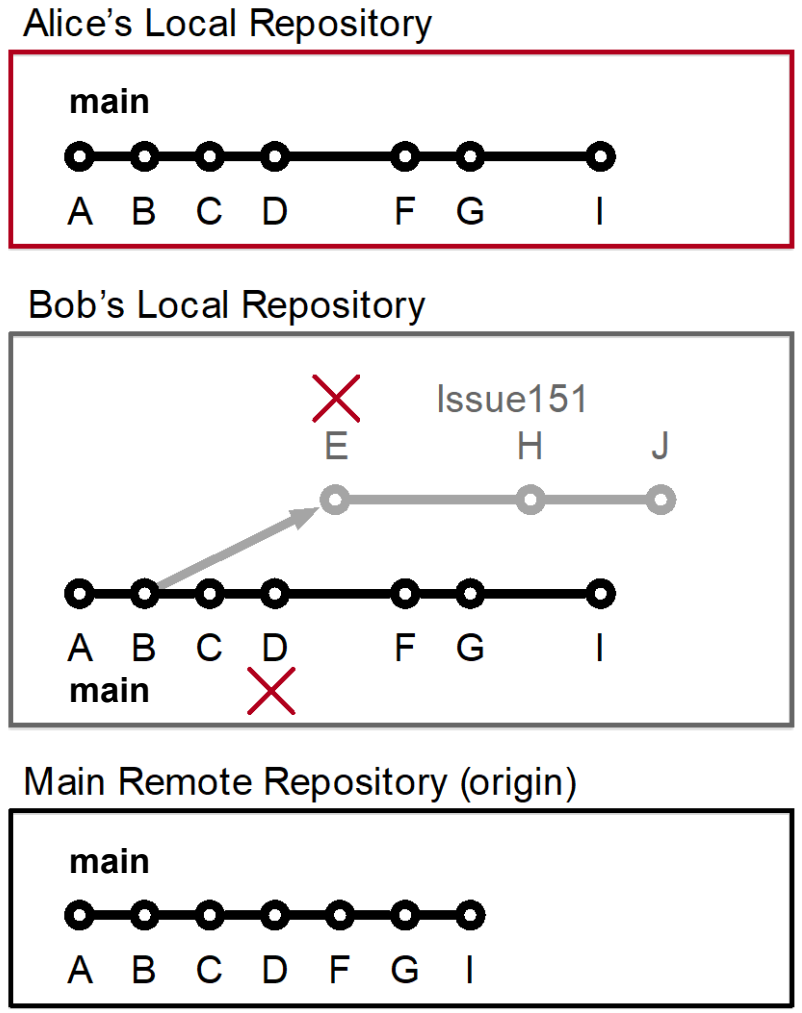
- Remote repo has commits A & B
- Bob pulls remote to synchronize local repo to remote
- Bob creates local feature branch based on commit B
- Commit C pushed to remote repo
- Alice pulls remote to synchronize local repo to remote
- Alice creates local feature branch based on commit C
- Both develop independently on local feature branches



Feature Branch Divergence

Alice integrates first without issue

- Alice does fast-forward merge to local main
- Alice deletes local feature branch
- Alice pushes main to remote
- Meanwhile, Bob pulls main from remote and finds Alice's changes
- Merge conflict between commits D and E

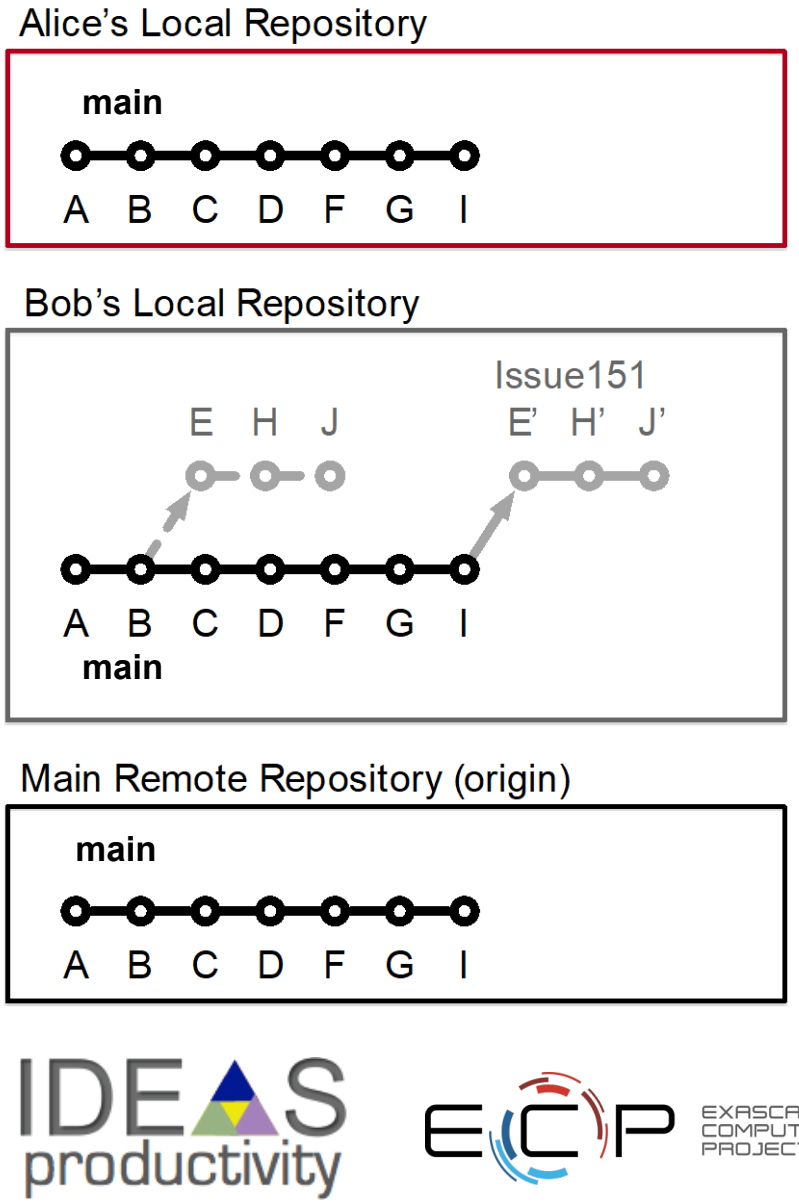


Feature Race Condition

Integration occurs on Bob's local repo

- Bob laments not having fast-forward merge
- Bob **rebases** local feature branch to latest commit on main
  - E based off of commit B
  - E' based off of Alice's commit I
  - E' is E integrated with commits C, D, F, G, I
- Merge conflict resolved by Bob & Alice on Bob's local branch when converting commit E into E'
- Can test on feature branch and merge easily and cleanly

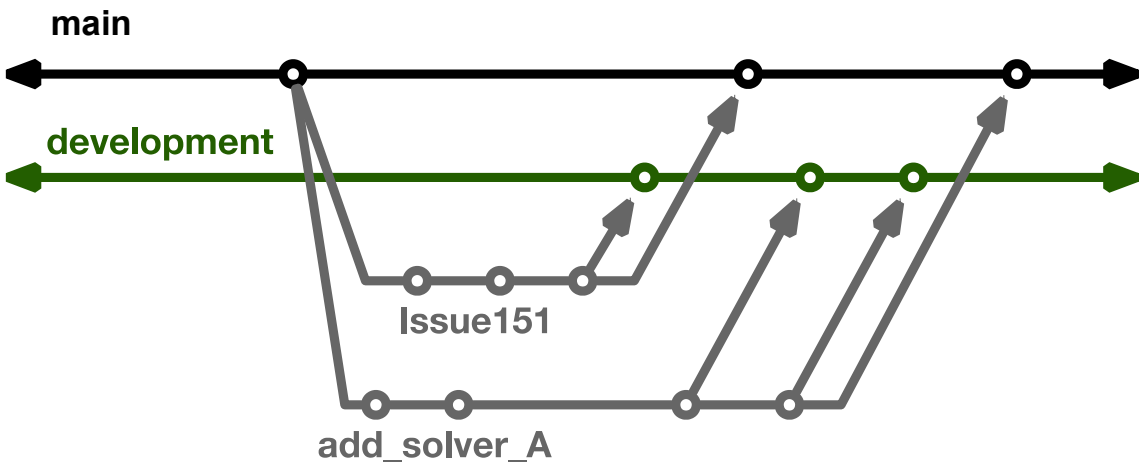
- See Atlassian/BitBucket for a richer Feature Branch Workflow



More Branches

Branches with infinite lifetime

- Base off of main branch
- Exist in all copies of a repository
- Each provides a distinct **environment**
  - Development vs. pre-production



Pull/Merge Requests (GitHub/GitLab)

- Code review and testing before merge
  - Alerts team and others about changes in branch before merge
  - Discussions ensue with possible follow up commits
  - Can request reviewer
- Set policies for merge
  - Enforce rules such as coding standards
  - Minimum number of reviewers
  - Protected braches

GitHub Forks

- A “fork” of a repository is a complete copy of another repository, inside a different GitHub account.
  - *Different* from a clone
- Forking requires read access to the *upstream* repository
  - Forks of public repositories are public
  - External collaborators can be granted write access to your fork
  - You cannot fork a fork
- Does not copy issues or pull requests
- Use branches within your fork (do not modify main)
- A pull/merge request can be used to suggest changes to the upstream repository
  - Added benefit: pull requests from forks prevent huge numbers of branches on the upstream repository

Code Review – What Peer Code Review Can Provide

- Allows discussion of proposed changes
  - Iterations for better code
  - Discussions and reviewing allow more understanding of the code
- Ensures requested change/feature met
- Evaluates impact of the change
  - Breakages
  - Interactions with other parts of code
- Ensures coding guidelines are met
- Improves practices by learning
  - About other parts of the code
  - Helpful coding techniques by others

Blog: **How to code review in a Pull Request**
Author: Hugo Sousa - March 17, 2021
https://blog.codacy.com/how-to-code-review-in-a-pull-request/

Code Review - Improvement and Practices

- Helpful practices for scientific research software
  - Make code review process formal with structured guidelines
  - Allocate sufficient time in the development process to perform code review
  - Try to ensure at least one science review and one technical review
  - Timely reviews - provide quick feedback to incoming review requests
  - Train reviewers on how to phrase good feedback
  - Train developers to accept comments to improve their code
  - Include automatic code review tool and train reviewers in best use practice of the tool

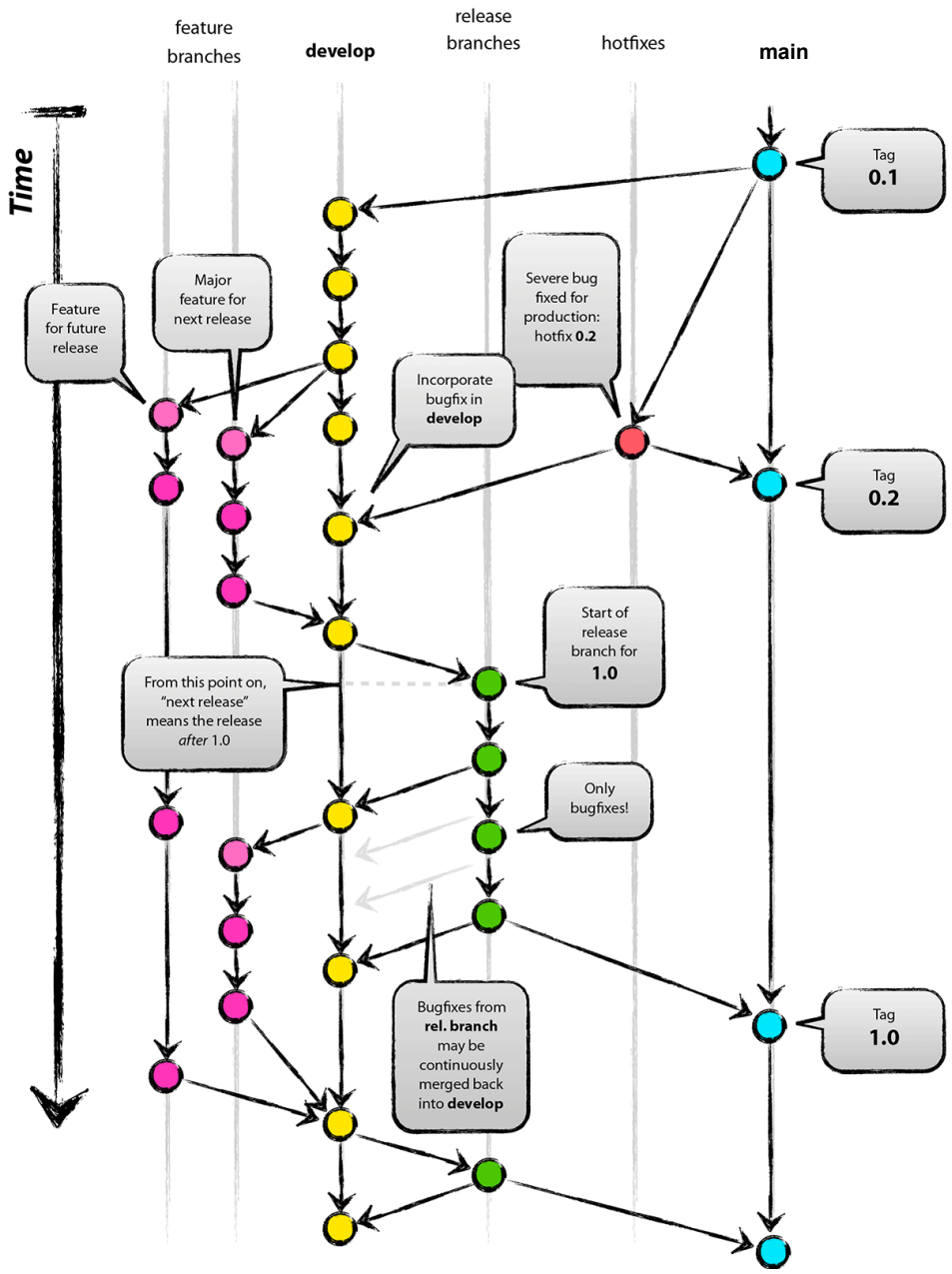
Testing and Code Review Practices in Research Software Development
Presenter: Nasir Eisty – September 9, 2020
https://ideas-productivity.org/events/hpc-best-practices-webinars/#webinar044

Git Workflow Models of Different complexity

Commonly Known Workflows

- Git Flow
- GitHub Flow
- GitLab Flow

Git Flow



- Full-featured workflow
- Increased complexity
- Designed for SW with official releases
- Feature branches based off of develop
- Git extensions to enforce policy
- How are develop and main synchronized?
- Where do merge conflicts occur and how are they resolved?

Author: Vincent Driessen
Original Blog: https://nvie.com/posts/a-successful-git-branching-model/
License: Creative Commons

GitHub Flow

http://scottchacon.com/2011/08/31/github-flow.html

- Published as viable alternative to Git Flow
- No structured release schedule
- Continuous deployment & continuous integration allows for simpler workflow

Key Ideas

1. All commits in the main branch are **deployable**
2. Base feature branches off of main
3. Push local repository to remote constantly
4. Open Pull Requests early to start dialogue
5. Merge into main after Pull Request review

GitLab Flow

https://docs.gitlab.com/ee/workflow/gitlab_flow.html

- Published as viable alternative to Git Flow & GitHub Flow
- Semi-structured release schedule
- Workflow that simplifies difficulties and common failures in synchronizing infinite lifetime branches

Key Ideas

- main branch is staging area
- Mature code in main flows downstream into pre-production & production infinite lifetime branches
- Allow for release branches with downstream flow
  - Fixes made upstream & merged into main.
  - Fixes cherry picked into release branch

Considerations for Choosing a Git Workflow

Want to establish a clear set of polices that

- results in correct code on a particular branch (usually main),
- ensures that a team can develop in parallel and communicate well,
- minimizes difficulties associated with parallel and distributed work, and
- minimizes overhead associated with learning, following, and enforcing policies.

Adopt what is good for your team

- Consider team culture and project challenges
- Assess what is and isn't feasible/acceptable
- Start with simplest and add complexity where and when necessary

Summary

- Distributed version control systems can introduce complexities due to their nature
  - Git provides a variety of mechanisms to aid collaboration
  - Hosting services provide additional collaboration mechanisms
- Workflows provide a way of enabling collaborating developers to work effectively
  - There are many different workflows, choosing the best one that suites your team

Collaboration using Git Workflows for CSE projects

- Trilinos Workflow
- Open MPI Workflow
- Flecsi Workflow

Current Trilinos Workflow

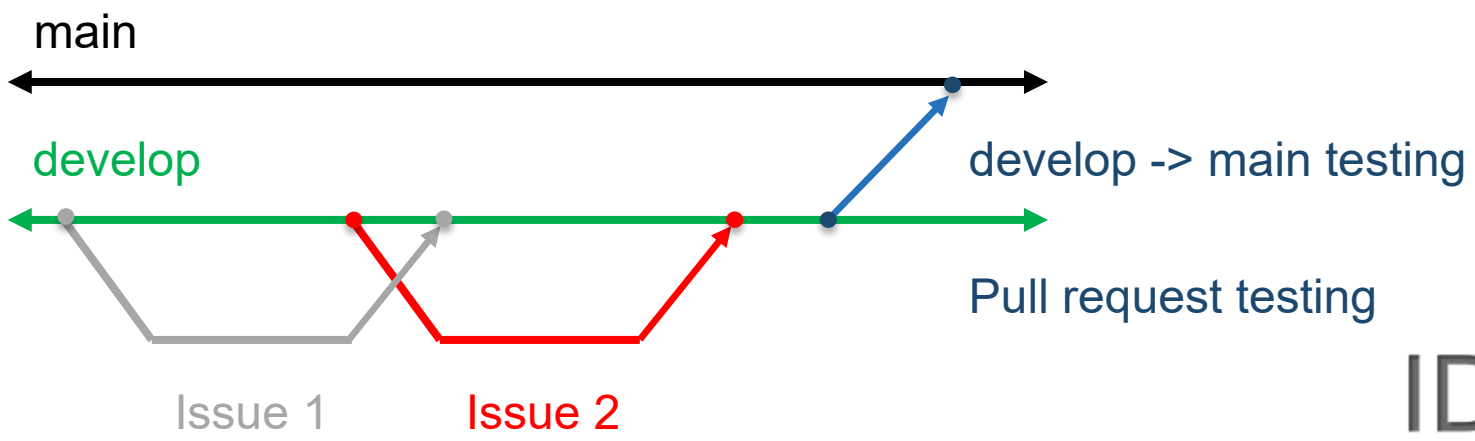
https://trilinos.github.io/

Test-driven workflow

- Feature branches start and end with develop
- All changes to develop must come from GitHub pull requests
- Feature branches are merged into develop only after passing pull request test suite
- Change sets from develop are tested daily for integration into main

Workflow designed so that

- All commits in main are in develop
- Merge conflicts exposed when integrating into develop
- Merge conflicts never occur when promoting to main



Current Open MPI Workflow

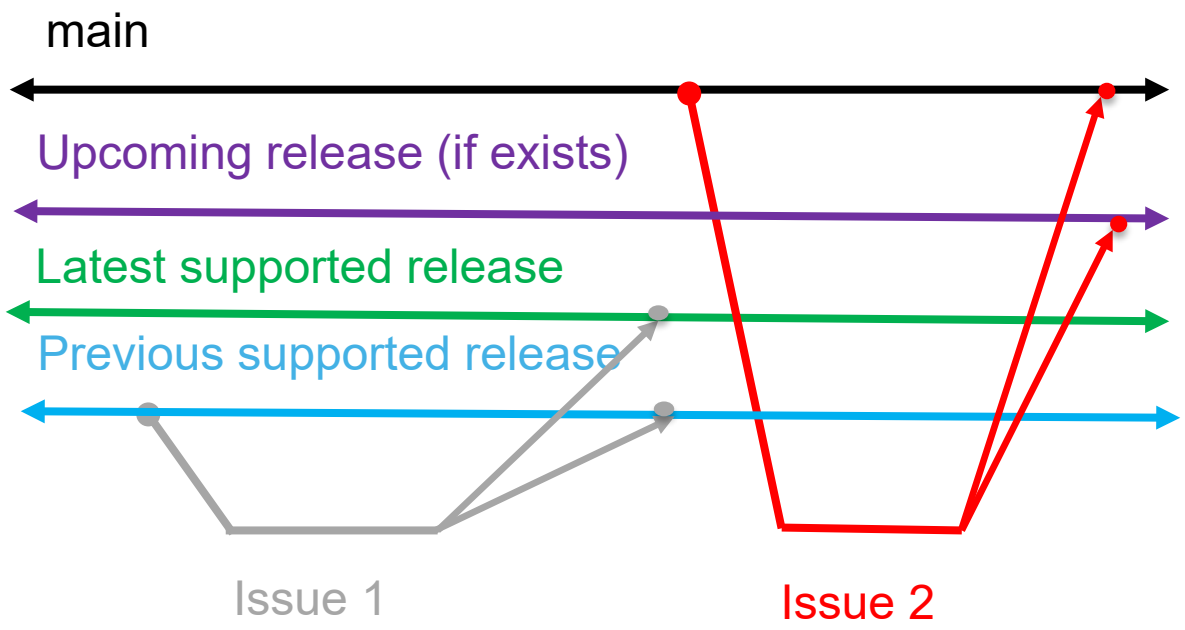
https://www.open-mpi.org

Versioning:

Major versions - break compatibility

Minor versions – visible

Releases correct issues



Workflow designed so that

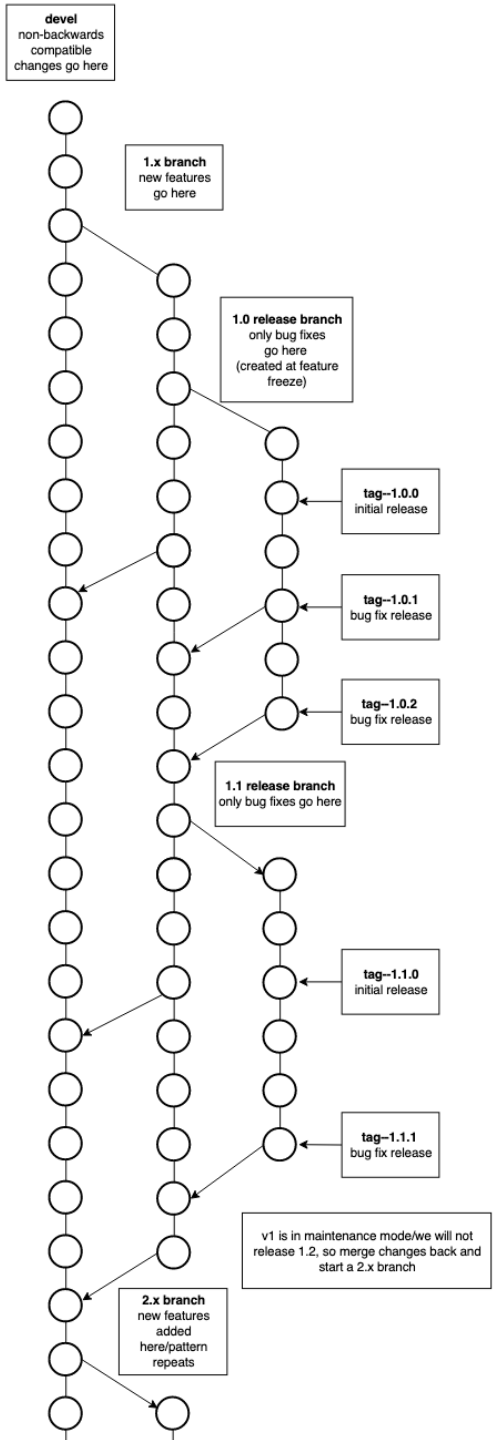
- Support two most recent releases
- Issues are addressed on all applicable branches
- All PR's reviewed by at least one core developer
- Main and supported branches work at all times
- Developers work on main or feature branches depending on complexity of the changes

Testing

- CI testing on PR's for any branch using Jenkins (limited set of compilers, hardware, tests)
- Nightly testing on all branches using community-built MTT framework (more complex set of compilers, hardware, tests)
- Additional testing for release candidates

Current FleCSI Workflow

https://flecsi.github.io/flecsi



Versioning:

Incompatible - **devel** branch breaks compatibility with previous versions

Feature (1, 2 …) named for major version

Release - **(1.x, 2.x …)** named for major.minor version, correct issues, tags used for bug fixes.

Workflow designed so that

- All supported branches work at all times
- Merge Requests are tested and reviewed

Testing

- Customized unit-testing framework based on Google Test
- Special *gitlab-ci* branch - images and configuration files

IDEAS productivity

ECP EXASCALE COMPUTING PROJECT