Git Workflows

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Better Scientific Software tutorial @ SC21

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- **The requested citation the overall tutorial is: David E. Bernholdt, Anshu Dubey, Patricia A. Grubel, Rinku K. Gupta, and Gregory R. Watson, Better Scientific Software tutorial, in the International Conference for High-Performance Computing, Networking, Storage, and Analysis (SC21), St. Louis, MO, USA and online, 2021. DOI: 10.6084/m9.figshare.16556628**
- Individual modules may be cited as *Speaker, Module Title*, in Better Scientific Software tutorial…

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Content

- Goal using Version Control with Git
- Git Workflow Mechanisms for Collaboration
  - Branches
  - 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

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Goal

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

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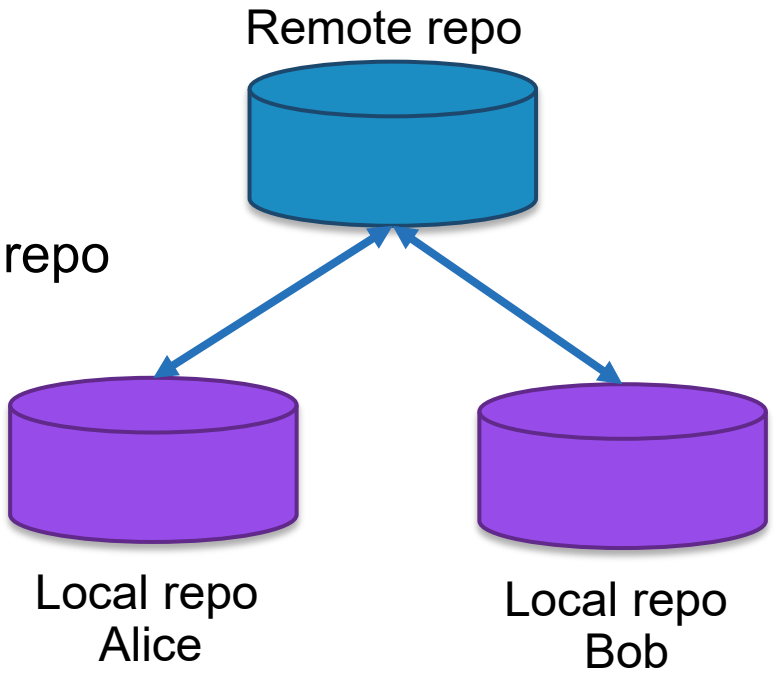
First Workflow

This process of collaborating *via* Git is called the **Centralized Workflow**

- See Atlassian/BitBucket for more information
- “Simple” to learn and “easy” to use
- Leverages local vs. remote repo dimension
  - Integration in local repo when local repos interact with remote repo
- 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?
- Working directly on the main branch



Git Workflow Mechanisms for Collaboration

- Branches
  - Enable separate development for features or fixes on the same repo
  - Enables different types of Workflows
- Pull Requests
  - Enables code review and testing before merge
- Forks
  - Enables contributions from external collaborators that have read access only
  - Controls on original repo remains with the team

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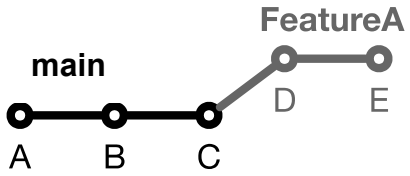
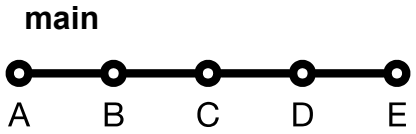
Branches

Branches are independent lines of development

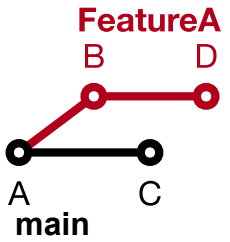
- Use branches to protect main branch
- Feature branches
  - Organize a new feature as a sequence of related commits in a branch
- Branches are usually combined or **merged**
- Develop on a branch, test on the branch, and merge into main
- Integration occurs at merge commits



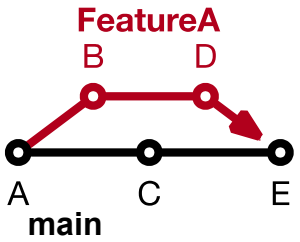
Fast-Forward



No Merge



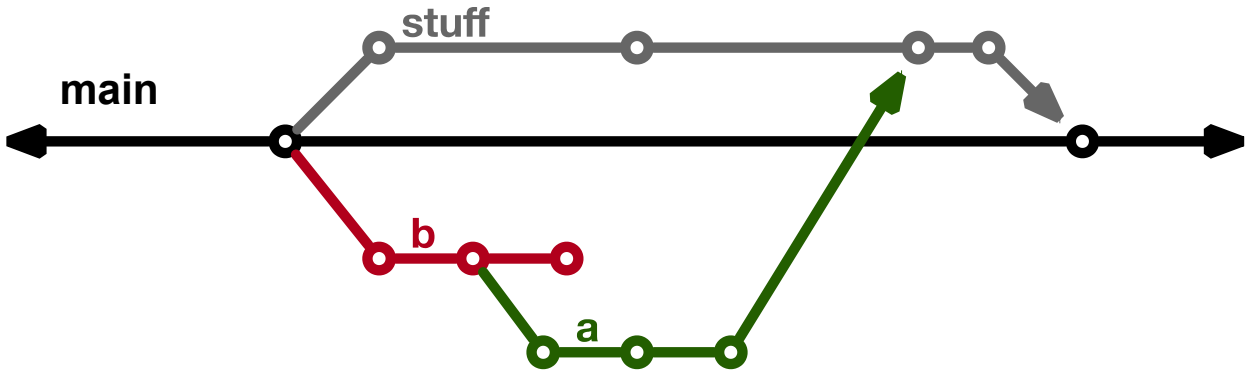
Divergence



Merge Commit

Control Project Branch Complexity

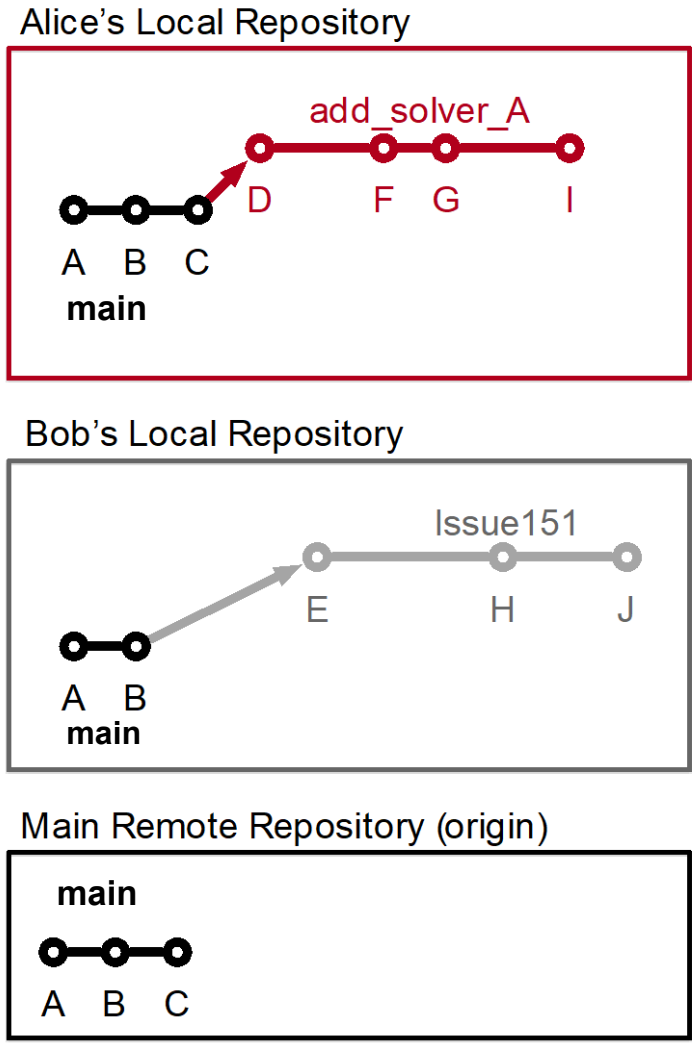
- Workflow policy is needed
  - Project supported branches and workflows should not be unnecessarily complex
  - Individuals and sub-teams can leverage more complex models when advantageous
  - Descriptive names or linked to issue tracking system
  - Where do branches start and end?



Feature Branches

Extend Centralized Workflow

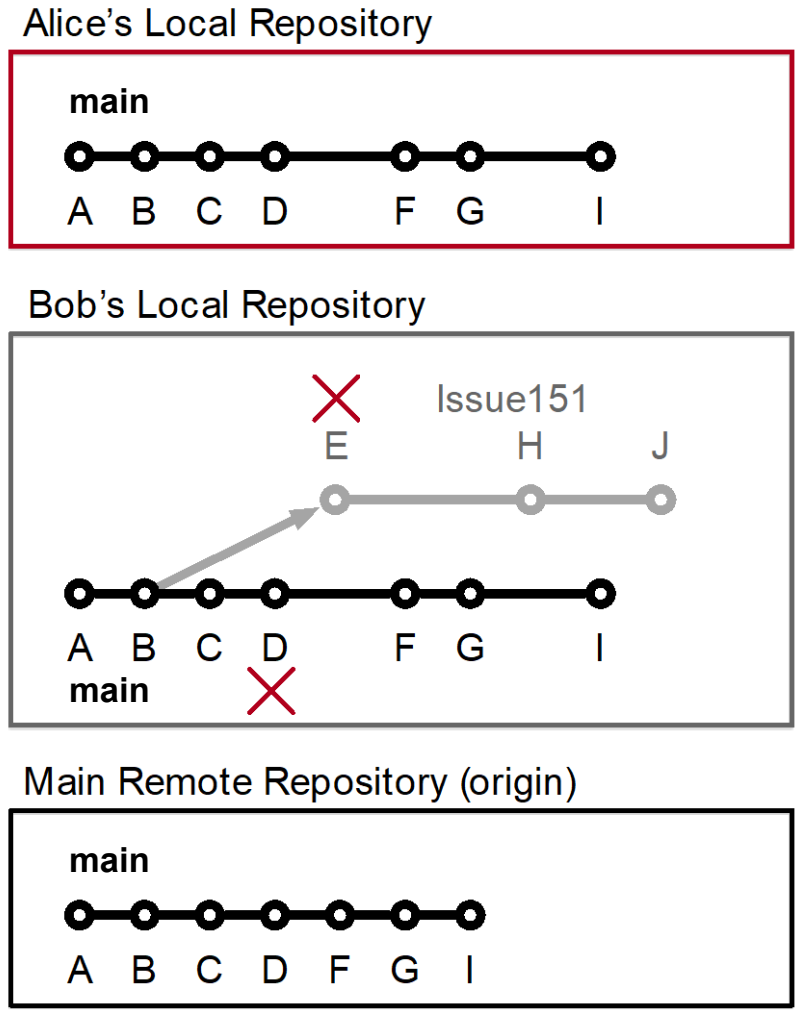
- Remote repo has commits A & B
- Bob pulls remote to synchronize local repo to remote
- Bob creates local feature branch based on commit B
- Commit C pushed to remote repo
- Alice pulls remote to synchronize local repo to remote
- Alice creates local feature branch based on commit C
- Both develop independently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

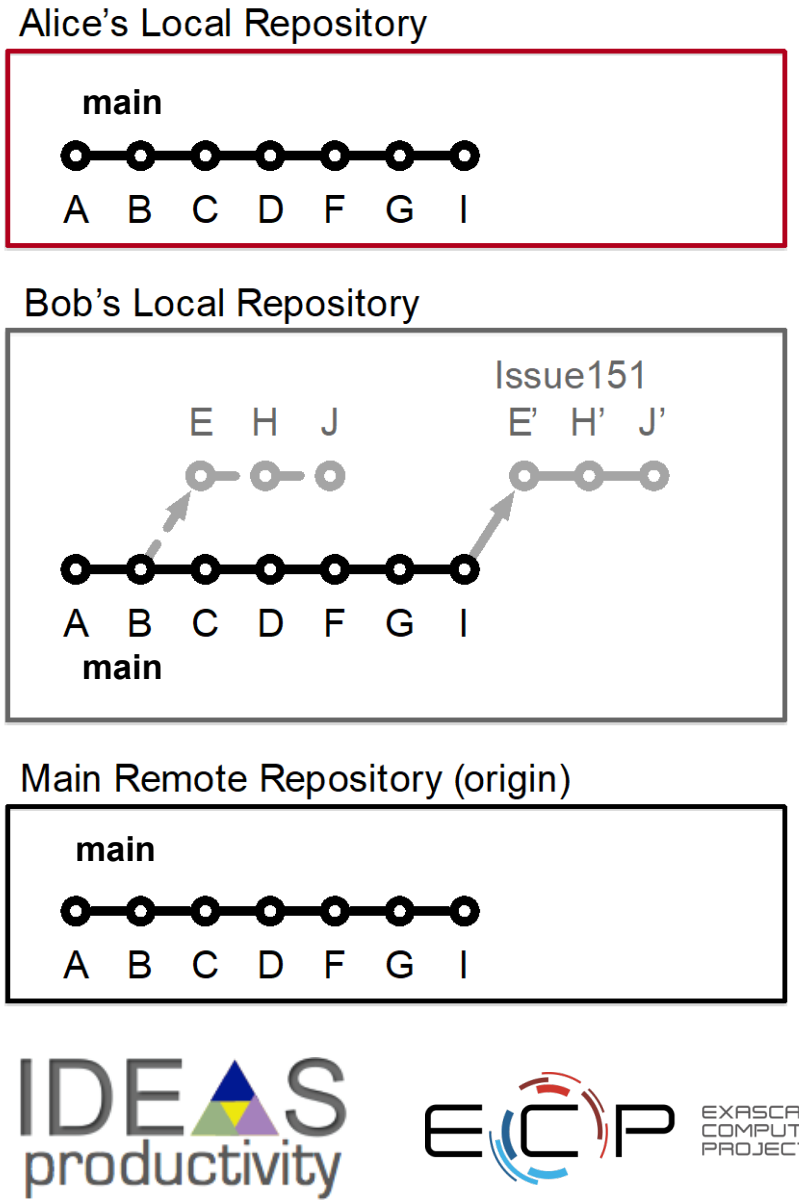


Feature Race Condition

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

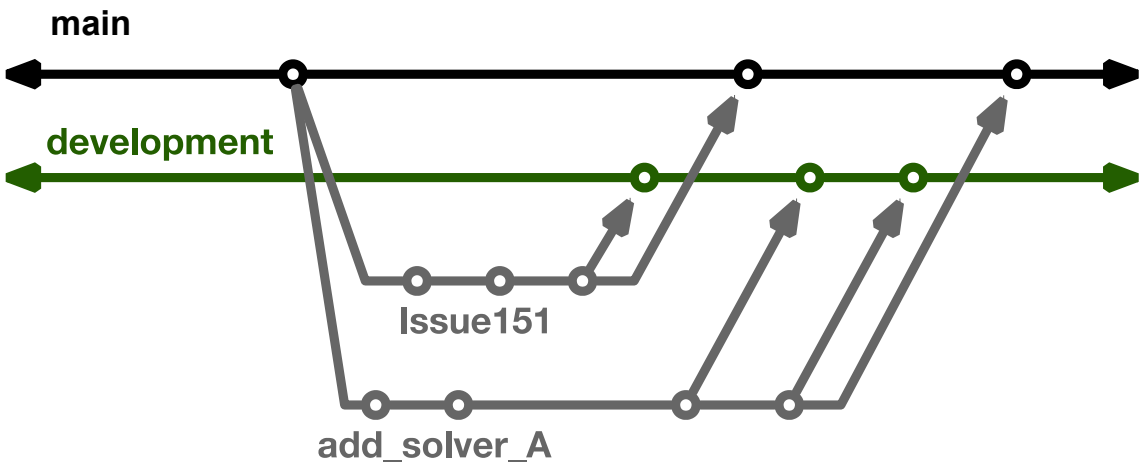
- See Atlassian/BitBucket for a richer Feature Branch Workflow



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



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Pull Requests

- 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

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GitHub Forks

- A “fork” of a repository is a complete copy of another repository, inside a different GitHub account.
  - 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 request (GitLab uses “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

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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/

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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

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Git Workflow Models of Different complexity

Commonly Known Workflows

- Git Flow
- Github Flow
- Gitlab Flow

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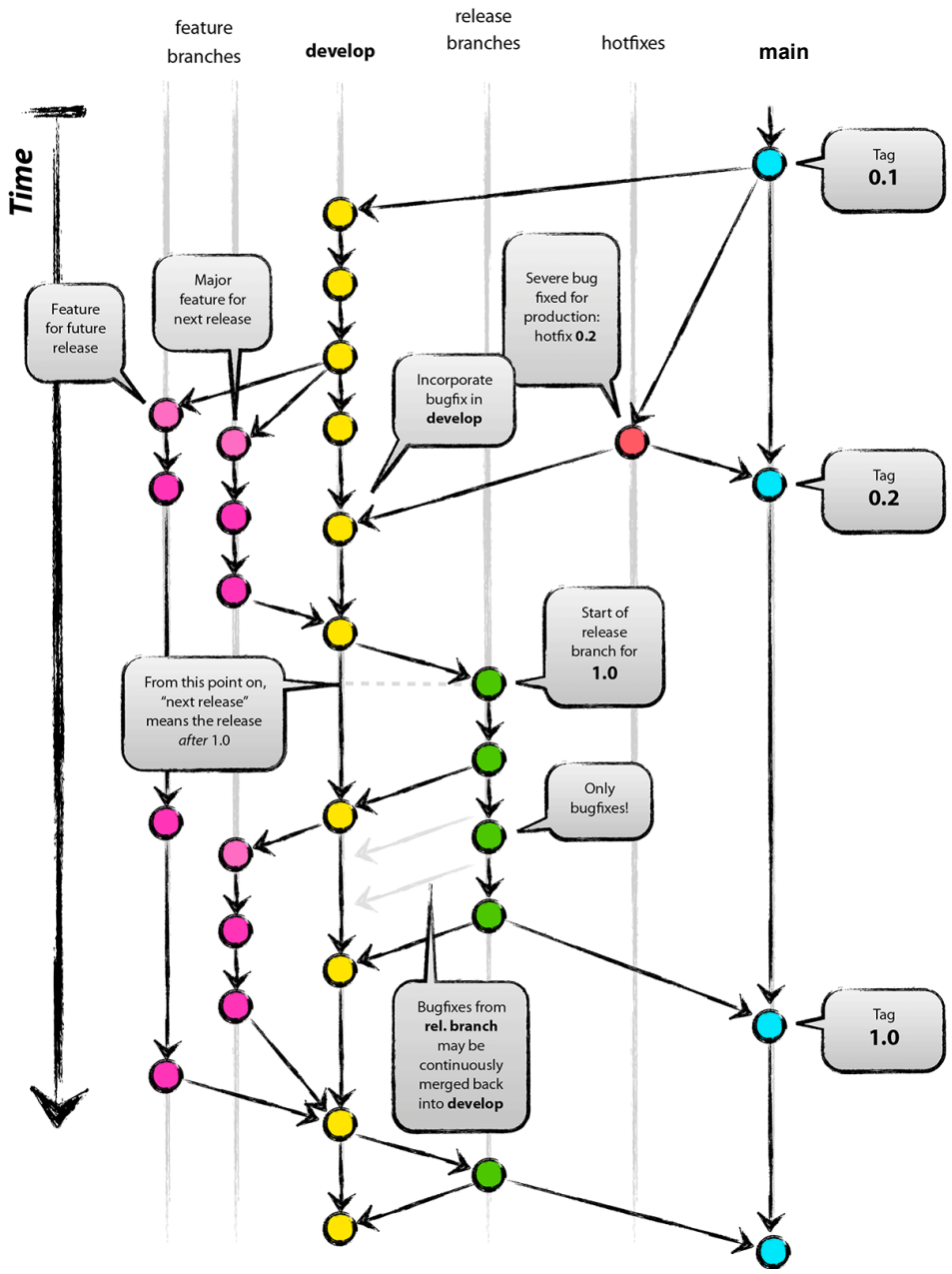
Git Flow



- 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/
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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

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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

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Collaboration using Git Workflows for CSE projects

- Trilionos Workflow
- Open MPI Workflow
- Flecsi Workflow

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Current Trilinos Workflow

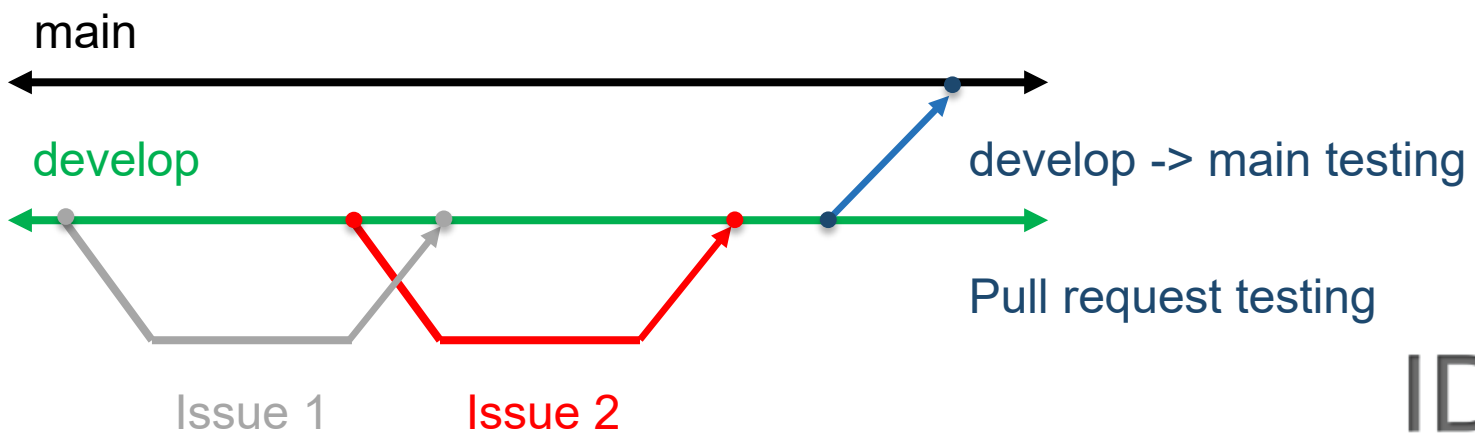
https://trilinos.github.io/

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

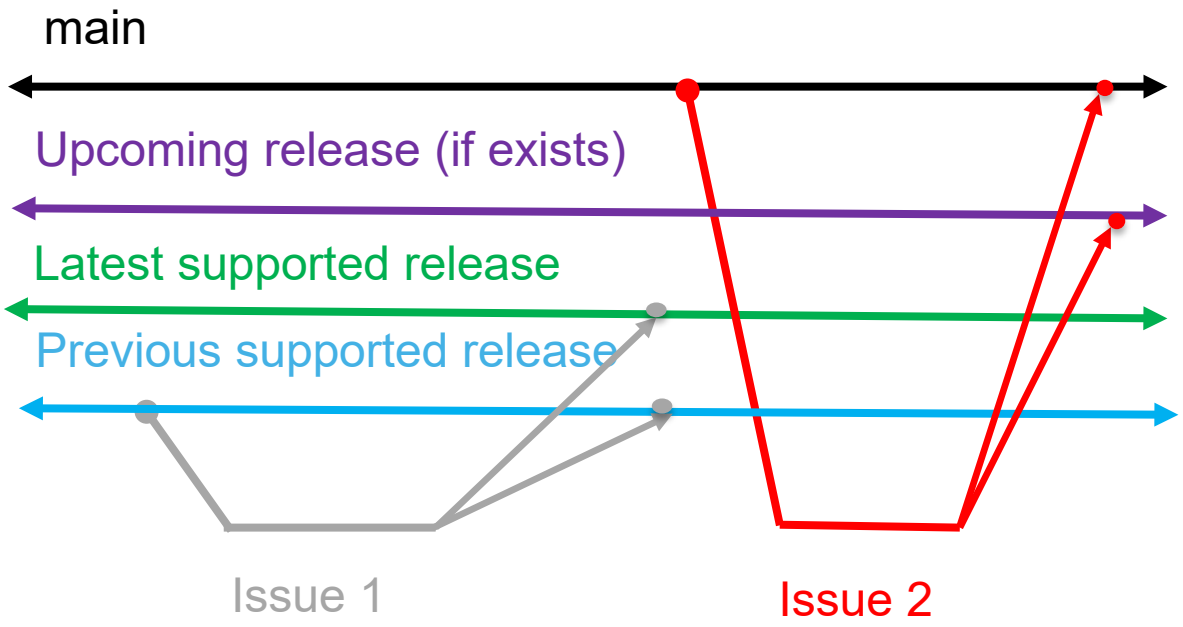
https://www.open-mpi.org

Versioning:

Major versions - break compatibility

Minor versions – visible

Releases correct issues



Workflow designed so that

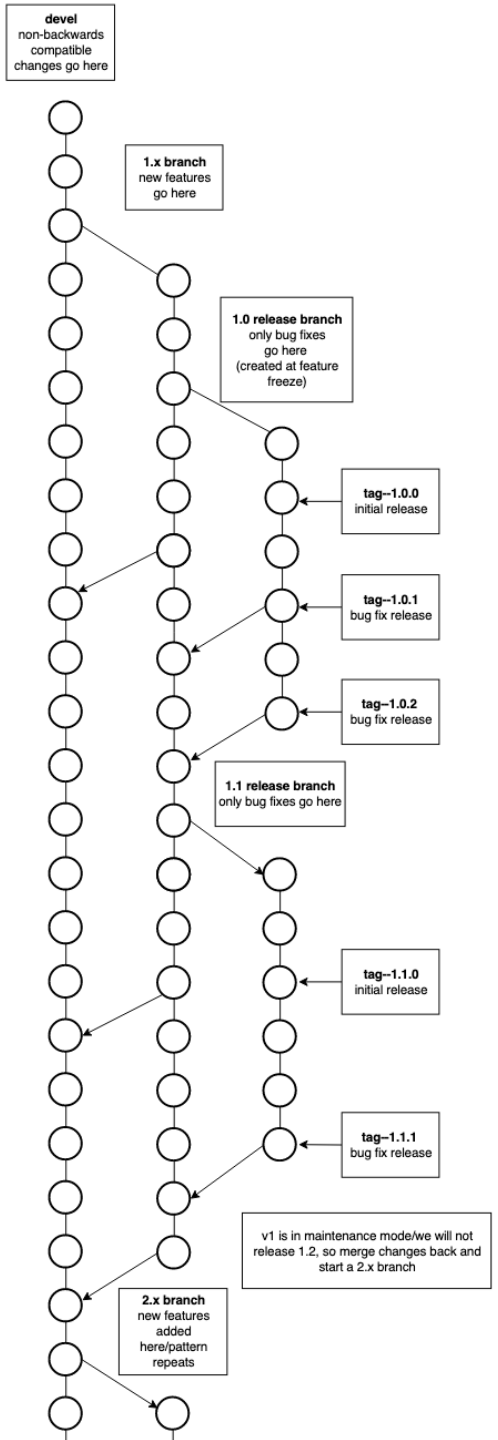
- Support two most recent releases
- Issues are addressed on all applicable branches
- All PR's reviewed by at least one core developer
- Main and supported branches work at all times
- Developers work on main or feature branches depending on complexity of the changes

Testing

- CI testing on PR's for any branch using Jenkins (limited set of compilers, hardware, tests)
- Nightly testing on all branches using community-build 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

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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

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