Git Workflows

Better Scientific Software Tutorial

Jared O’Neal
Mathematics and Computer Science Division
Argonne National Laboratory

Supercomputing 2018
Dallas, TX
November 12, 2018

License, citation, and acknowledgments

License and Citation

- Requested citation: Jared O'Neal, Git Workflows, Better Scientific Software tutorial, in SC '18: International Conference for High Performance Computing, Networking, Storage and Analysis, Dallas, Texas, 2018. DOI: 10.6084/m9.figshare.7304171.

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
- Anshu Dubey, Klaus Weide, Saurabh Chawdhary, and Carlo Graziani
- Iulian Grindeanu

Goals

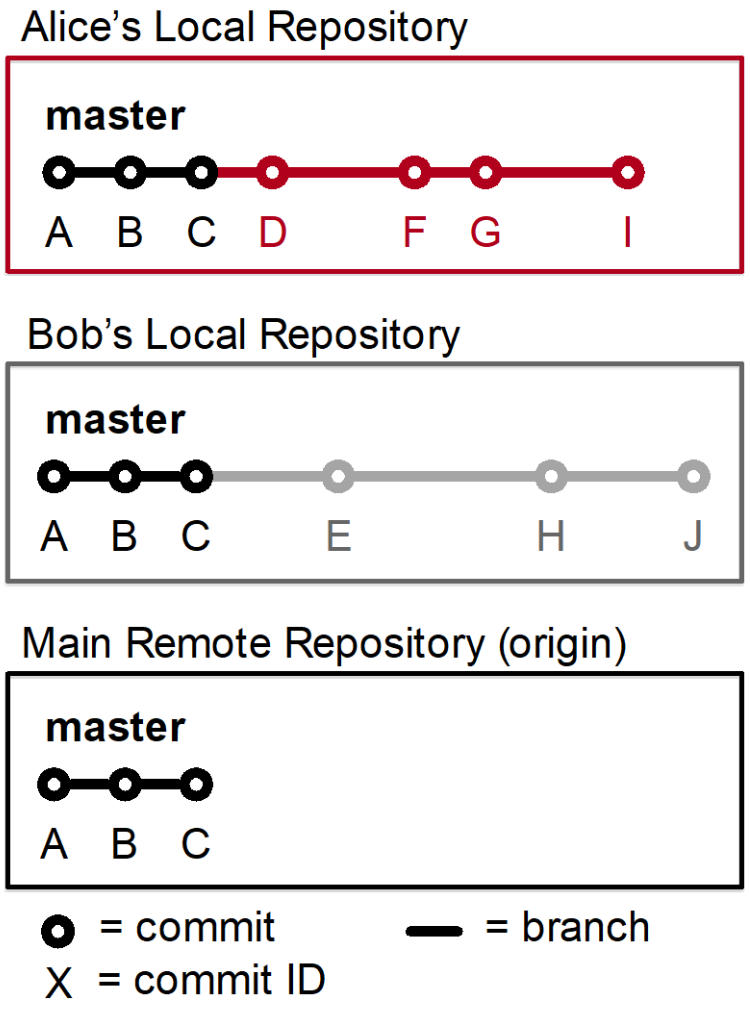
Development teams would like to use version control to collaborate productively and ensure correct code

- Understand challenges related to parallel code development *via* distributed version control
- Understand extra dimensions of distributed version control & how to use them
  – Local vs. remote repositories
  – Branches
  – Issues, Pull Requests, & Code Reviews (next talk)
- Exposure to workflows of different complexity
- What to think about when evaluating different workflows
- Motivate continuous integration

Distributed Version Control System (DVCS)

Two developers collaborating *via* Git

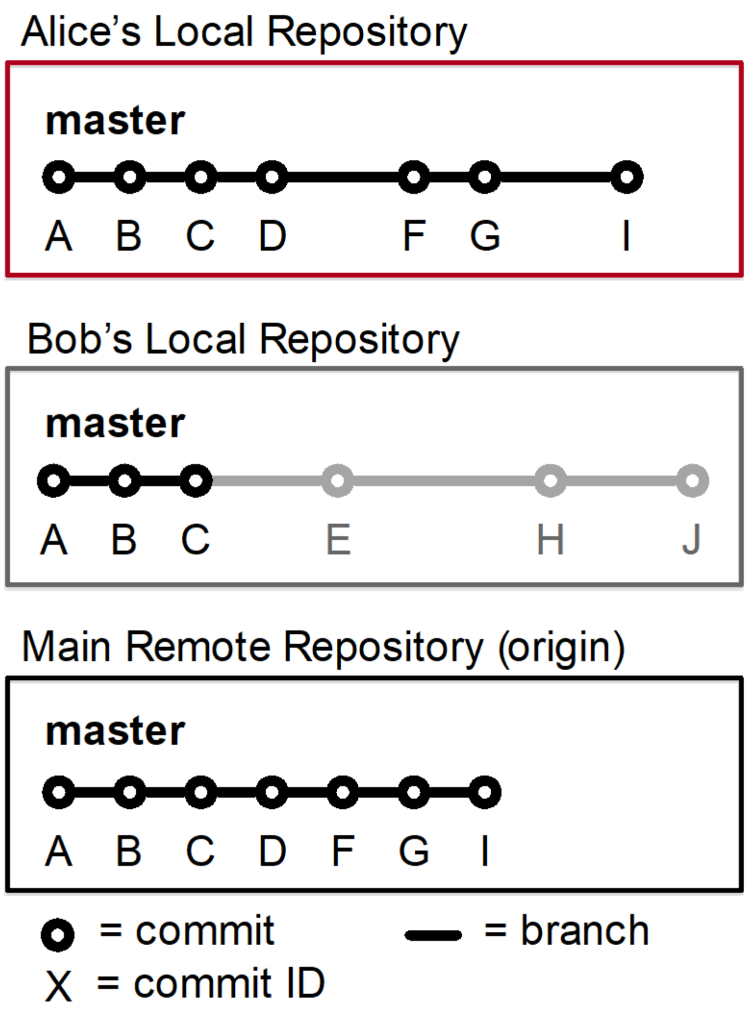
- Local copies of master branch synched to origin
- Each develops on **local** copy of master branch
- All copies of master immediately diverge
- How to **integrate** work on origin?



DVCS Race Condition

Integration of independent work occurs when local repos interact with remote repo

- Alice pushes her local commits to remote repo first
- No integration conflicts
- No risk
- Alice's local repo identical to remote repo

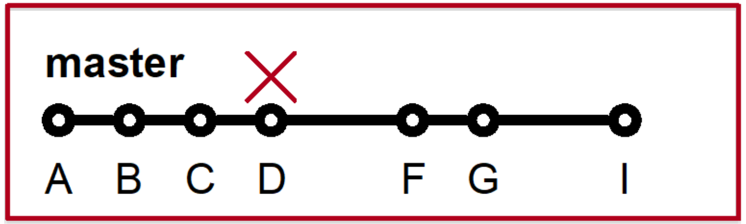


Integration Conflicts Happen

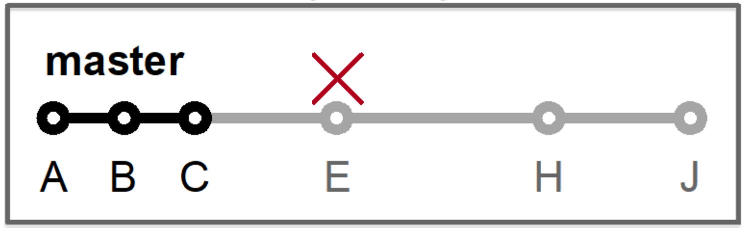
Bob's push to remote repo is rejected

- Alice updated code in commit D
- Bob updated same code in commit E
- Alice and Bob need to study conflict and decide on resolution at pull (time-consuming)
- Possibility of introducing bug on master branch (risky)

Alice's Local Repository



Bob's Local Repository



loops.cpp (commit C)

```
    // TODO: Code very important loop here ASAP


            ...


    // TODO: Code other very important loop here ASAP

```

loops.cpp (commit D)

```
    // Very important loop
    for (int i=0; i<N; ++i) {

            ...

    // Another very important loop
    for (int i=1; i<=N; ++i) {
        foo[i] = bar[i] * i;

```

loops.cpp (commit E)

```
    // Very important loop
    for (int i=0; i<N; i++) {

            ...

    // Another very important loop
    for (int i=0; i<N; i++) {
        foo[i] = bar[i] * i;

```

Our First Workflow

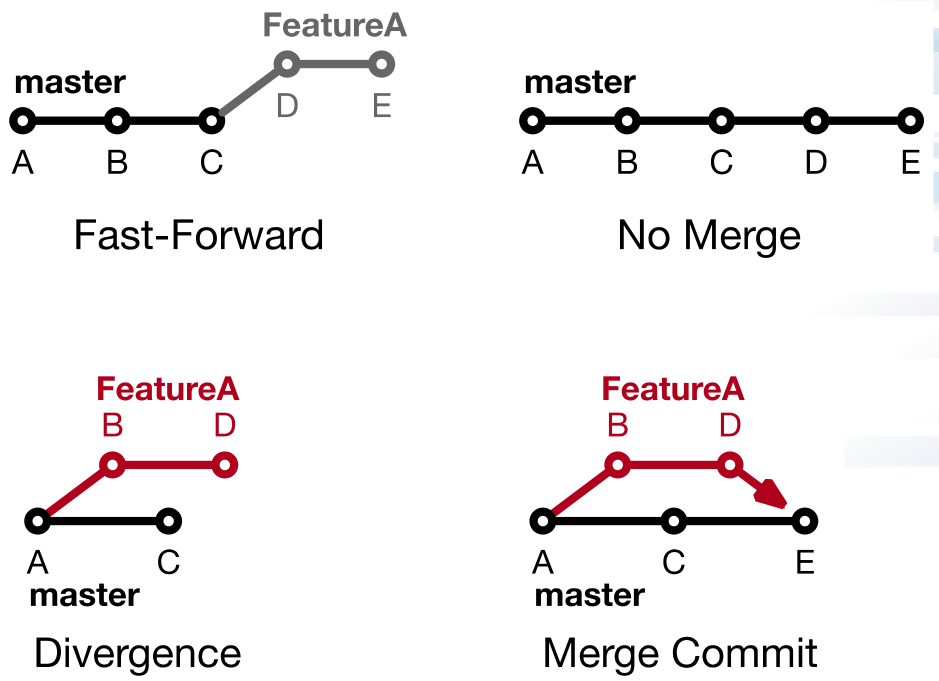
This process of collaborating *via* Git is called the **Centralized Workflow**

- 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?
- What if team members works on different parts of the code?
- Working directly on master

Branches

Branches are independent lines of development

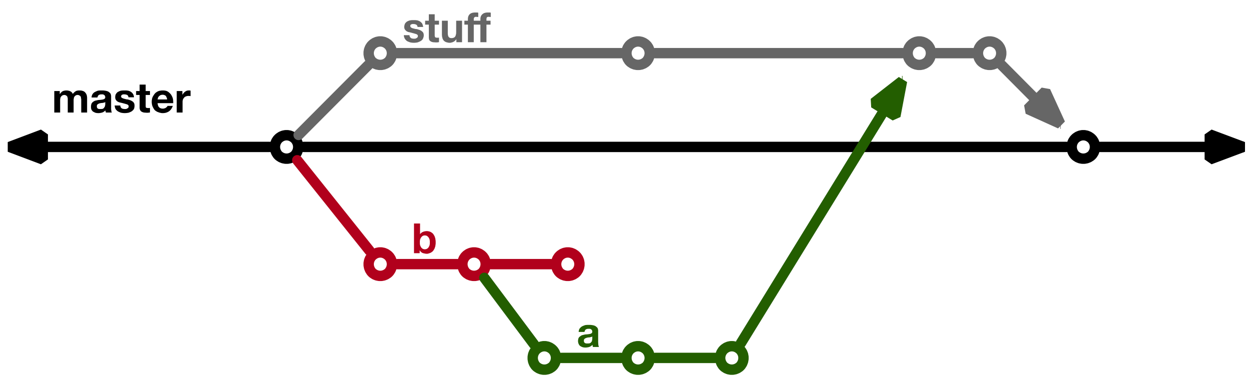
- Use branches to protect master branch
- Feature branches
  - Organize a new feature as a sequence of related commits in a branch
- Branches are usually combined or **merged**
- Develop on a branch, test on the branch, and merge into master
- Integration occurs at merge commits



Control Branch Complexity

Workflow policy is needed

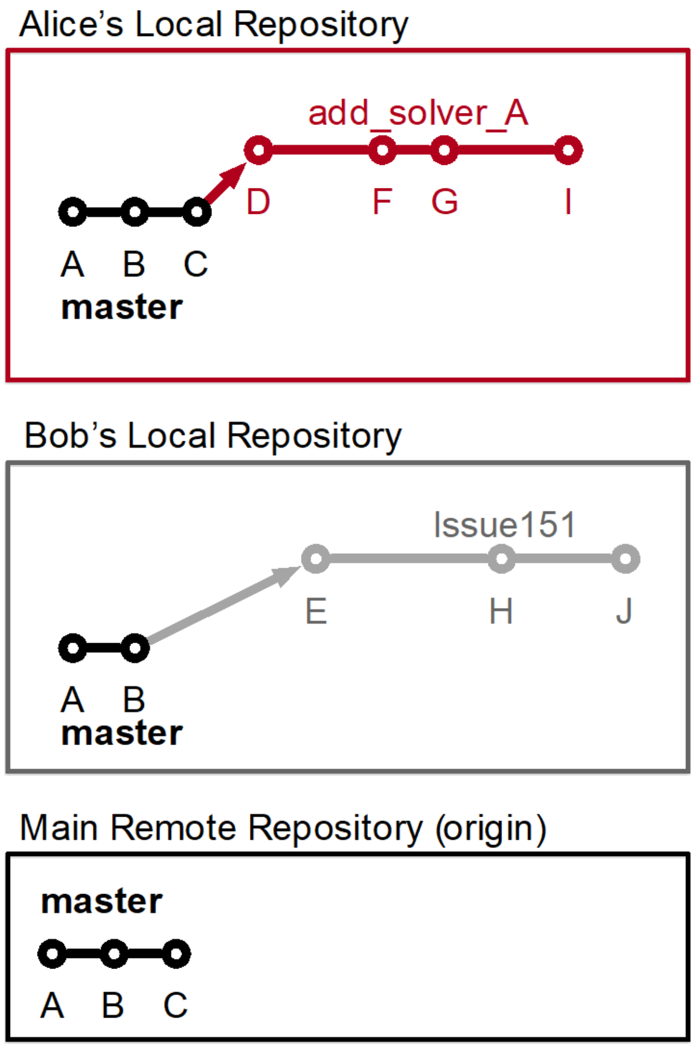
- Descriptive names or linked to issue tracking system
- Where do branches start and end?
- Can multiple people work on one branch?



Feature Branches

Extend Centralized Workflow

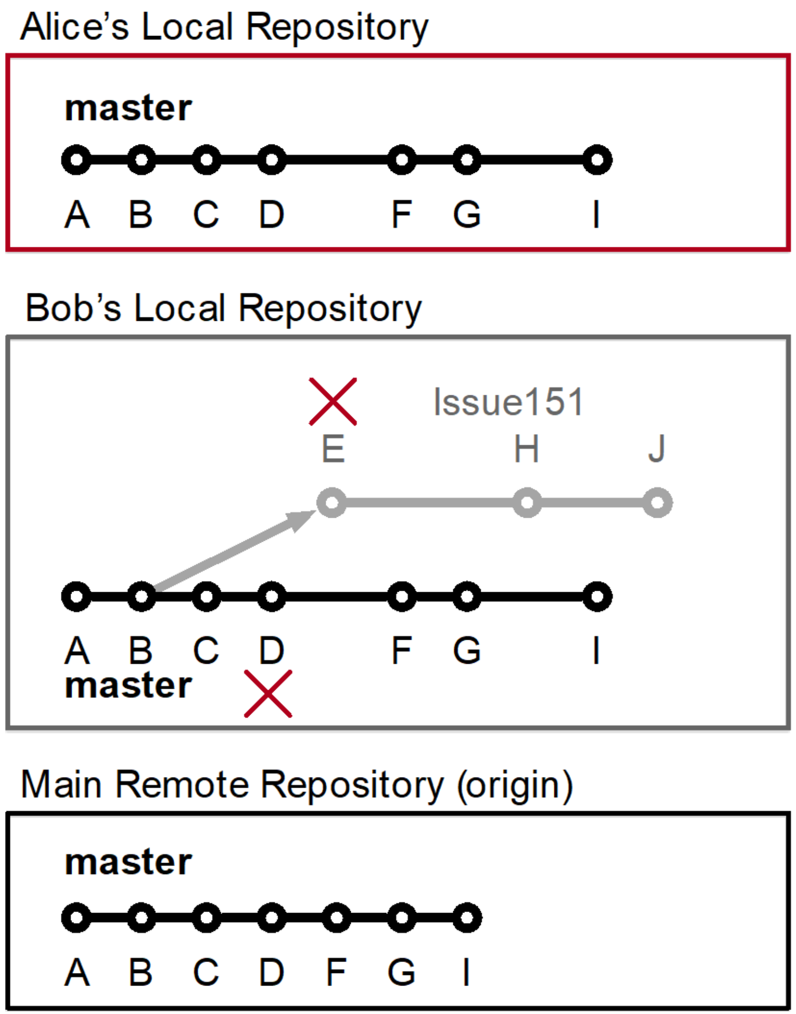
- Remote repo has commits A & B
- Bob pulls remote to synchronize local repo to remote
- Bob creates local feature branch based on commit B
- Commit C pushed to remote repo
- Alice pulls remote to synchronize local repo to remote
- Alice creates local feature branch based on commit C
- Both develop independently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



Feature Branch Divergence

Alice integrates first without issue

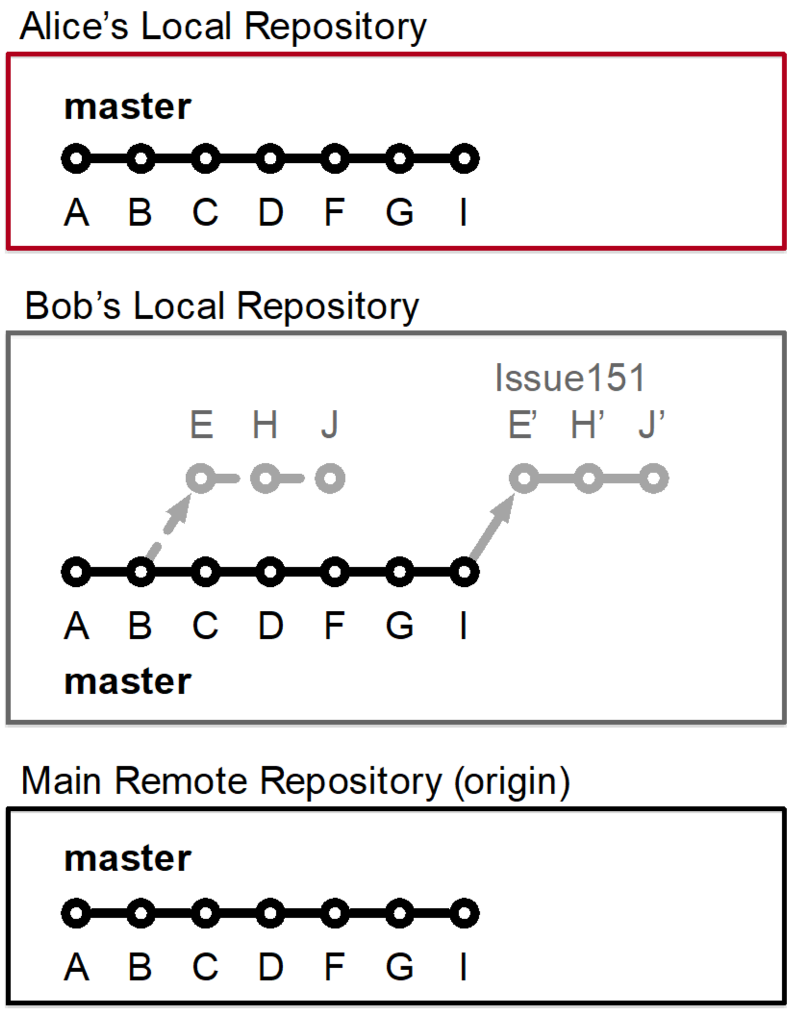
- Alice does fast-forward merge to local master
- Alice deletes local feature branch
- Alice pushes master to remote
- Meanwhile, Bob pulls master from remote and finds Alice's changes
- Merge conflict between commits D and E



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 master
  - 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



Feature Branches Summary

- Multiple, parallel lines of development possible on single local repo
- Easily maintain local master up-to-date and useable
- Integration with rebase on local repo is safe and can be aborted
- Testing before updating local and remote master branches
- Rebase is advanced Git command
  - Rebase can cause complications and should be used carefully.
- Hide actual workflow
  - History in repo is not represent actual development history
  - Less communication
  - Fewer back-ups using remote repo
- Does it scale with team size? What if team integrates frequently?
- Commits on master can be broken
- See Atlassian/BitBucket for a richer Feature Branch Workflow

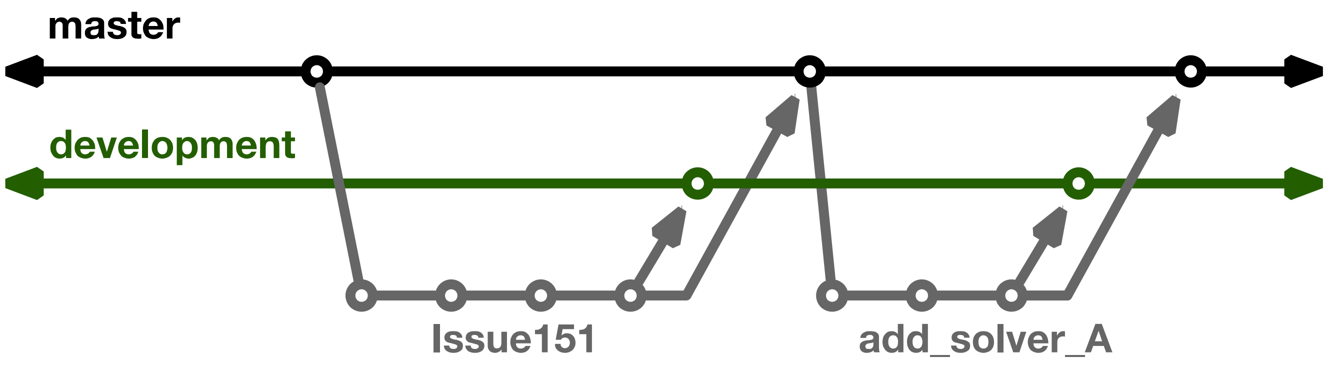
More Branches

Branches with infinite lifetime

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

For this example,

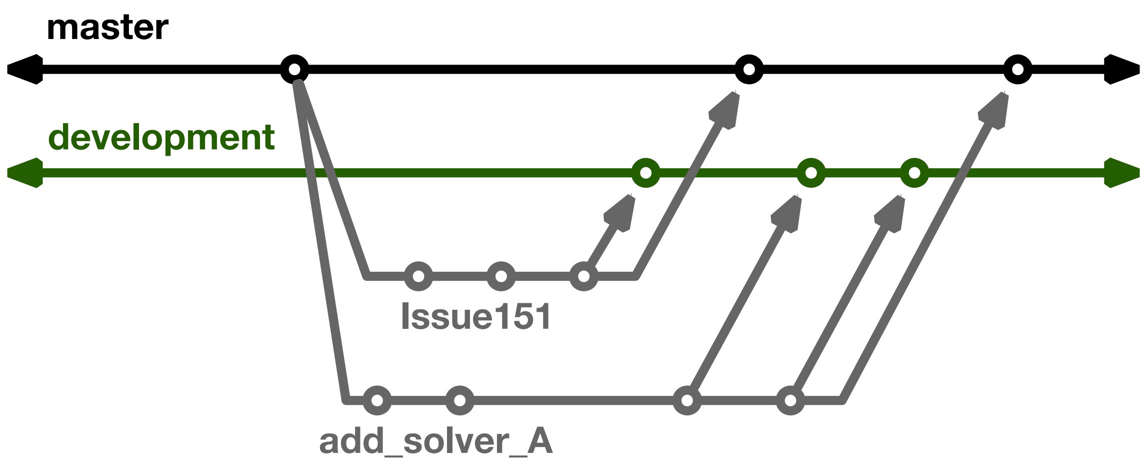
- All feature branches start and end on master
- Merge into development before merging into master
- No integration happening



Challenges

Multiple feature branches developed in parallel

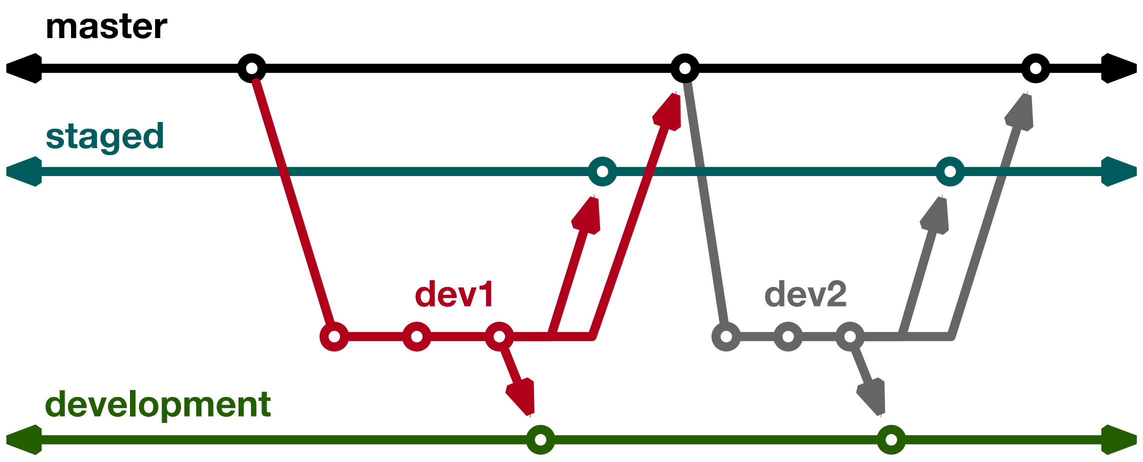
- All commits in master are in development
- Merge conflicts first exposed on development
- Set workflow so that infinite branches don't diverge



Current FLASH5 Workflow

Test-driven workflow

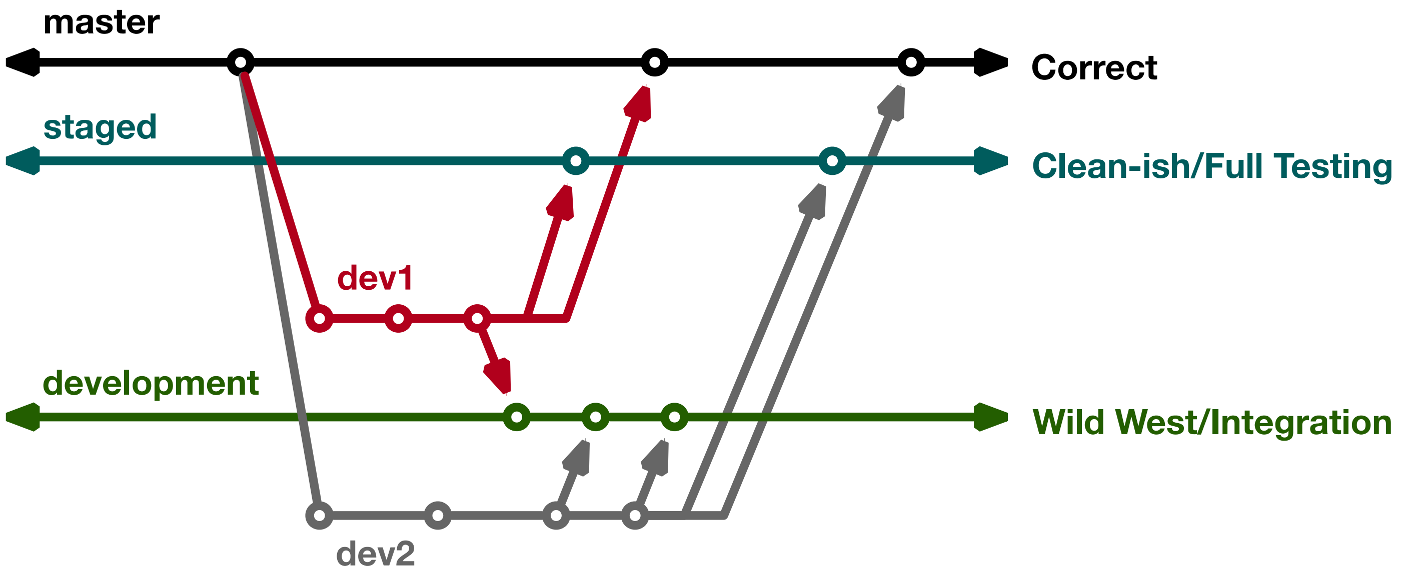
- Feature branches start and end with master
- All feature branches are merged into development for integration & manual testing
- All feature branches are then merged into staged for full, automated testing



More Branch Rules

Is staged really necessary?

- Contains only changes intended for master
- No integration means cleaner branch
- Allows for extra stage of testing with more tests
- Extra buffer for protecting master branch



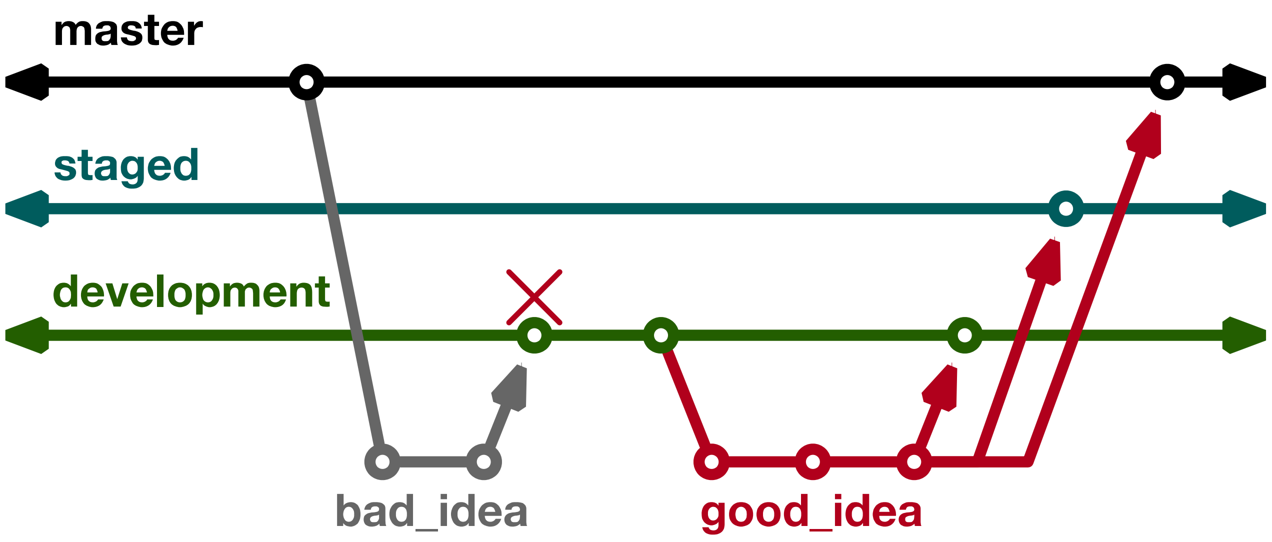
Branch Rules

Why base feature branches off master?

- Start from correct, verified commit
- Clean and simple to learn/enforce
- Isolate master from integration environment

Motivates more rules

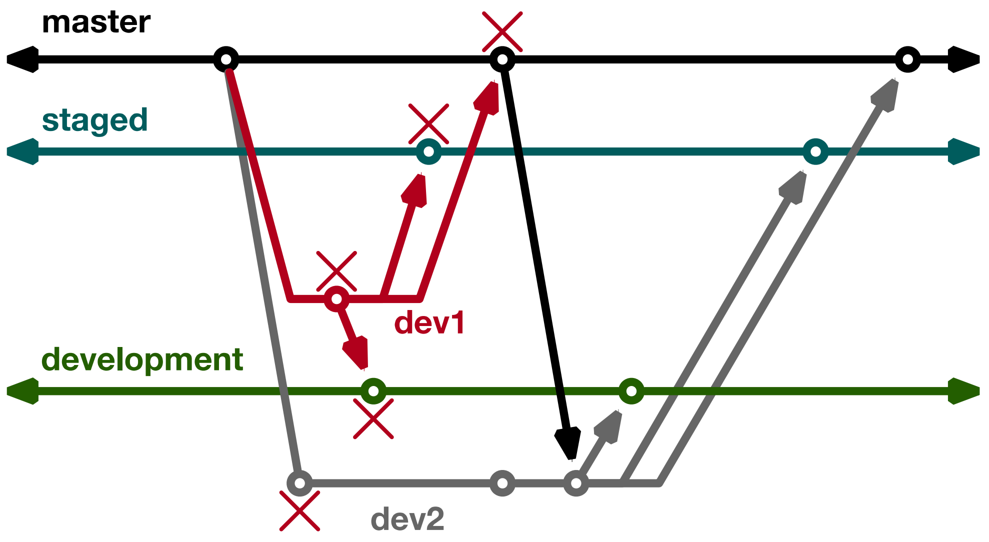
- Development never merged into another branch
- Staged never merged into another branch



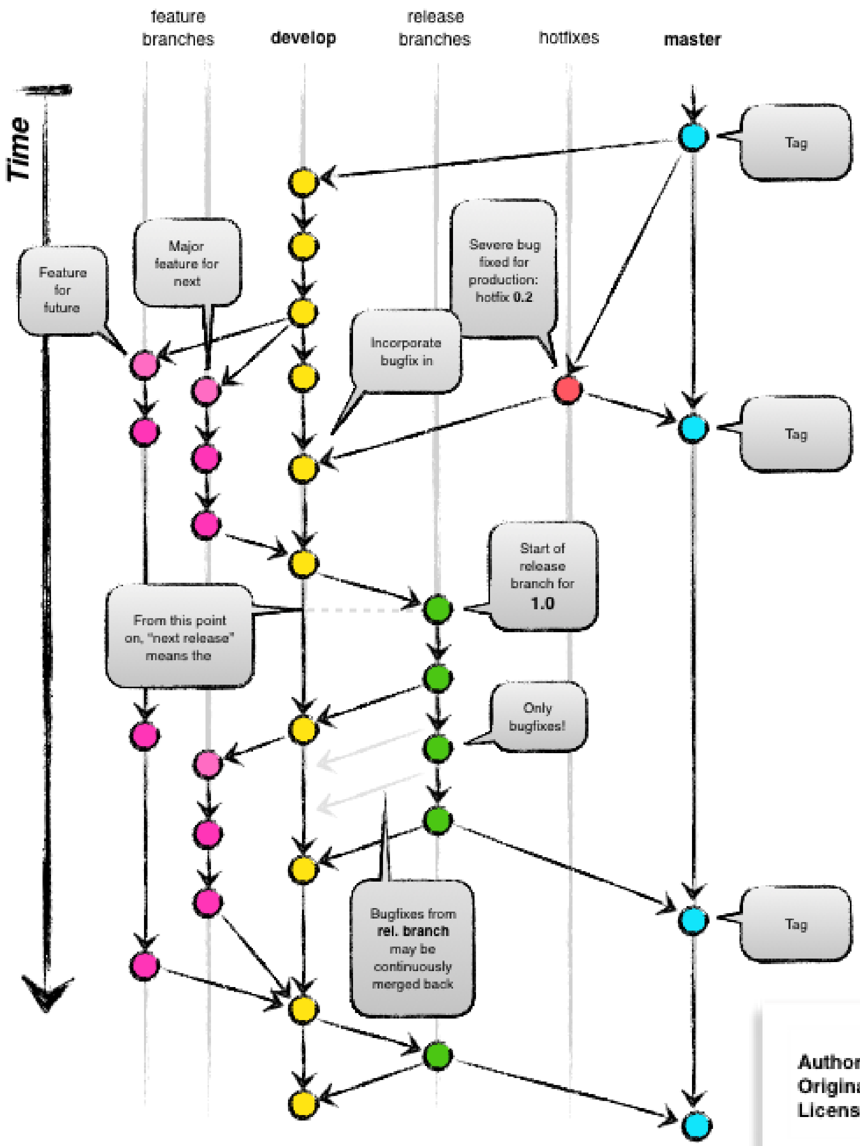
Merge Conflicts

How are merge conflicts resolved in FLASH5 Workflow?

- Merge conflict with master means merge conflict with staged and development
- We want to avoid conflict resolution when merging into master
- Directly on feature branch if resolution is there
- One idea is to merge master into feature branch



Git Flow



Author: Vincent Driessen
Original blog post: http://nvie.com/archives/323
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- 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 master synchronized?
- Where do merge conflicts occur and how are they resolved?

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

Main Ideas

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

Main Ideas

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

IDEAS productivity ECP EXASCALE COMPUTING PROJECT

Things to Think About When Choosing a Git Workflow

Want to establish a clear set of polices that

- results in correct code on a particular branch (usually master),
- 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.

Conclusions

Version control is an amazing tool

- Parallel and distributed working requires coordination and rules to be productive and produce correct code
- Appropriately chosen workflows can ensure quality results and help debugging/verification while helping productivity

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