Decentralized Version Control Systems

Matthieu Moy

Verimag

2007

Outline

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Backups: The Old Good Time

- Basic problems:
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  - Keep history:
    ```
    $ cp -r ~/project/ ~/backup/project-2006-10-4
    ```
  - Keep a description of history:
    ```
    $ echo "Description of current state" > \
        ~/backup/project-2006-10-4/README.txt
    ```

Backups: Improved Solutions

- Replicate over multiple machines
- Incremental backups: Store only the changes compared to previous revision
  - With file granularity
  - With finer-grained (diff)
- Many tools available:
  - Standalone tools: `rsync`, `rdiff-backup`, ...
  - Versionned filesystems: VMS, Windows 2003+, cvsfs, ...

Collaborative Development: The Old Good Time

- Basic problems: Several persons working on the same set of files
  1. "Hey, you've modified the same file as me, how do we merge?",
  2. "Your modifications are broken, your code doesn't even compile. Fix your changes before sending it to me!",
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  - People work trying to avoid conflicts, and merge later.

Merging: Problem and Solution

- My version

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#include <stdio.h>

int main () {
  printf("Hello");

  return EXIT_SUCCESS;
}
```

- Your version

```
#include <stdio.h>

int main () {
  printf("Hello!\n");

  return 0;
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Collaborative development linked to backups

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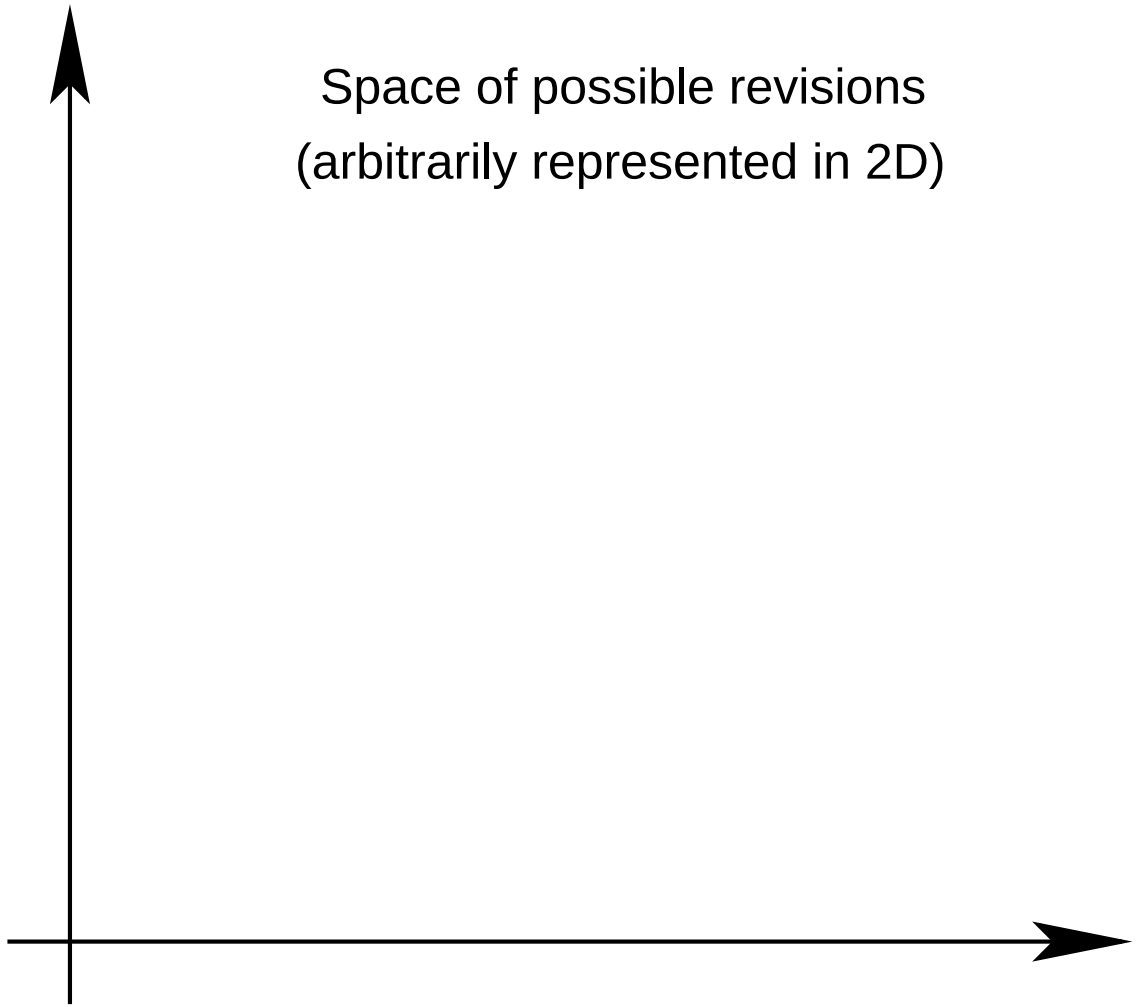
Space of possible revisions
(arbitrarily represented in 2D)

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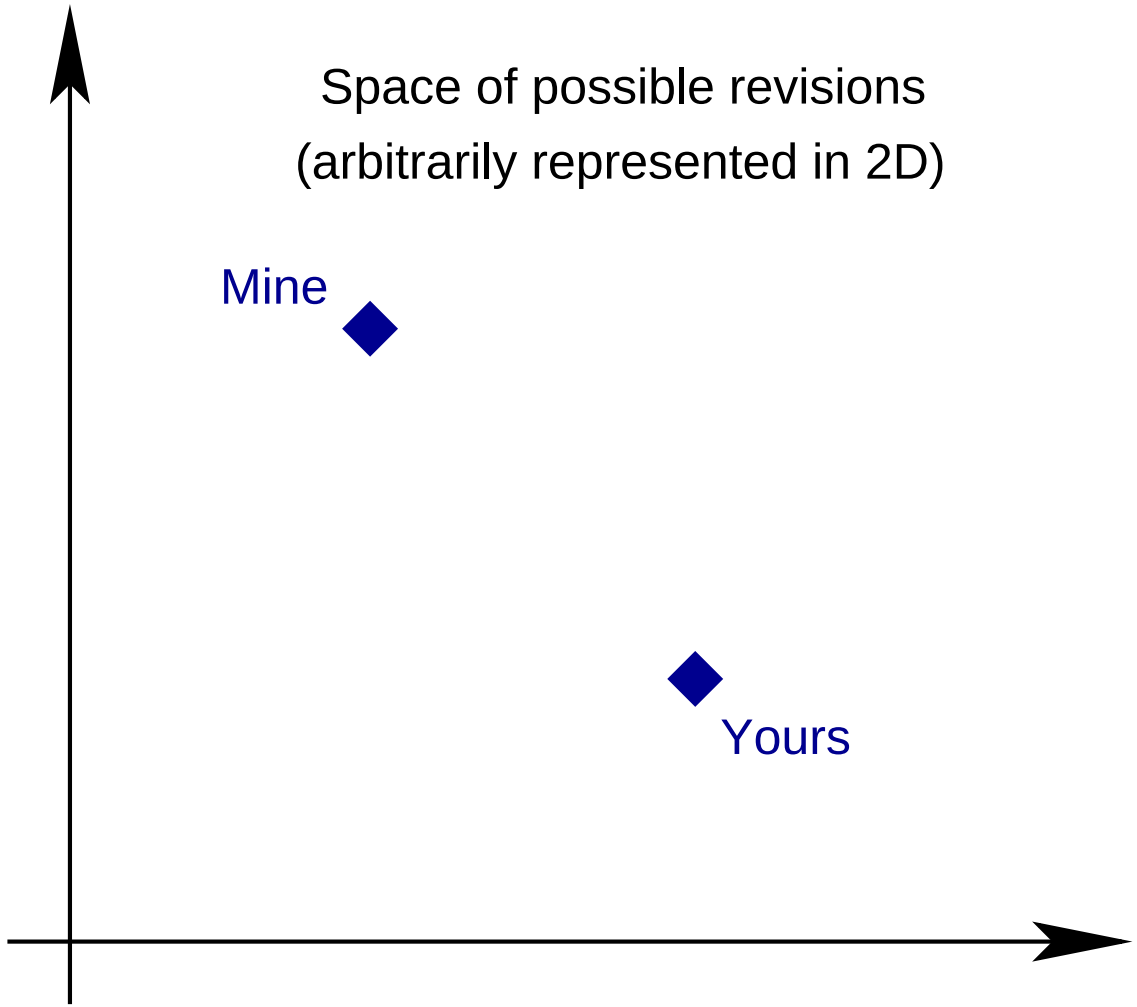
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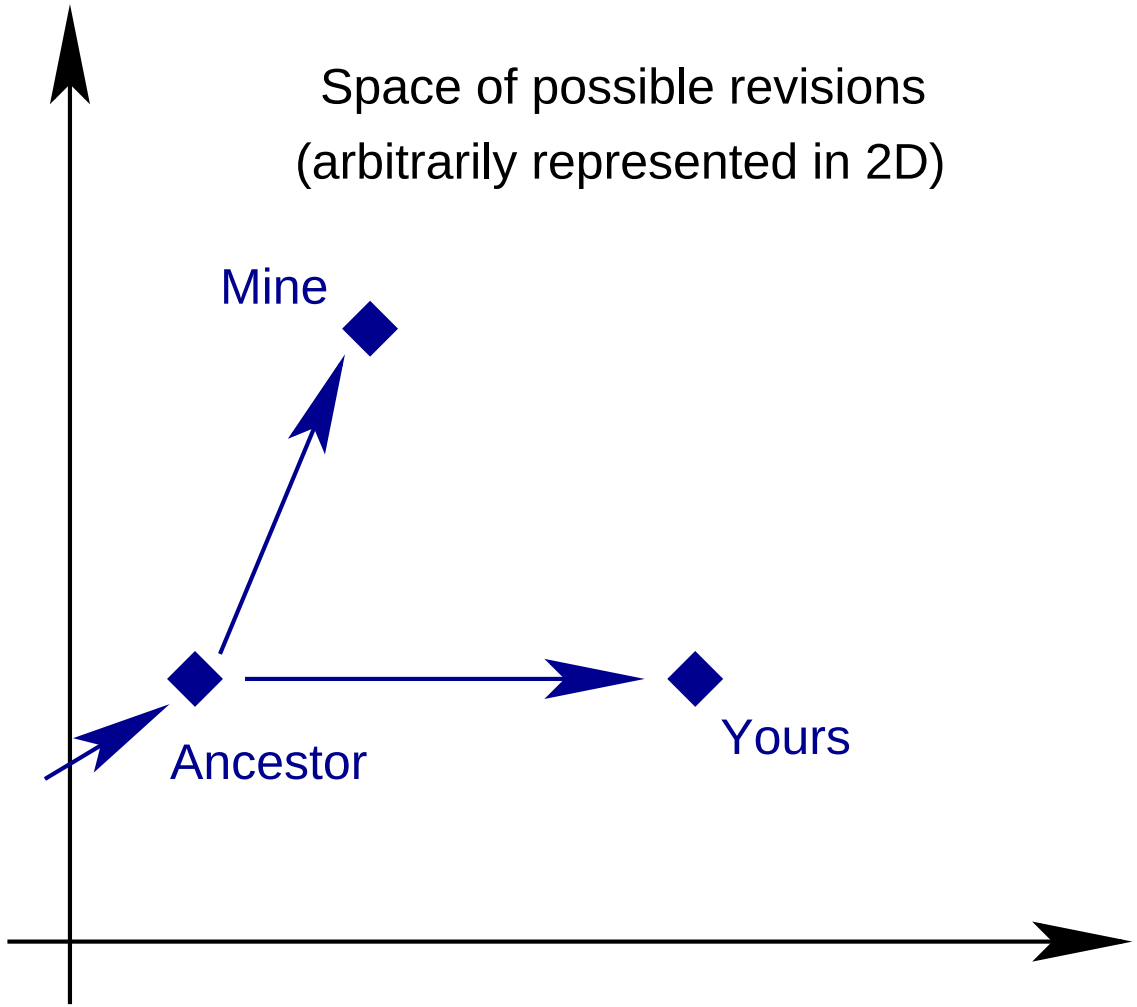
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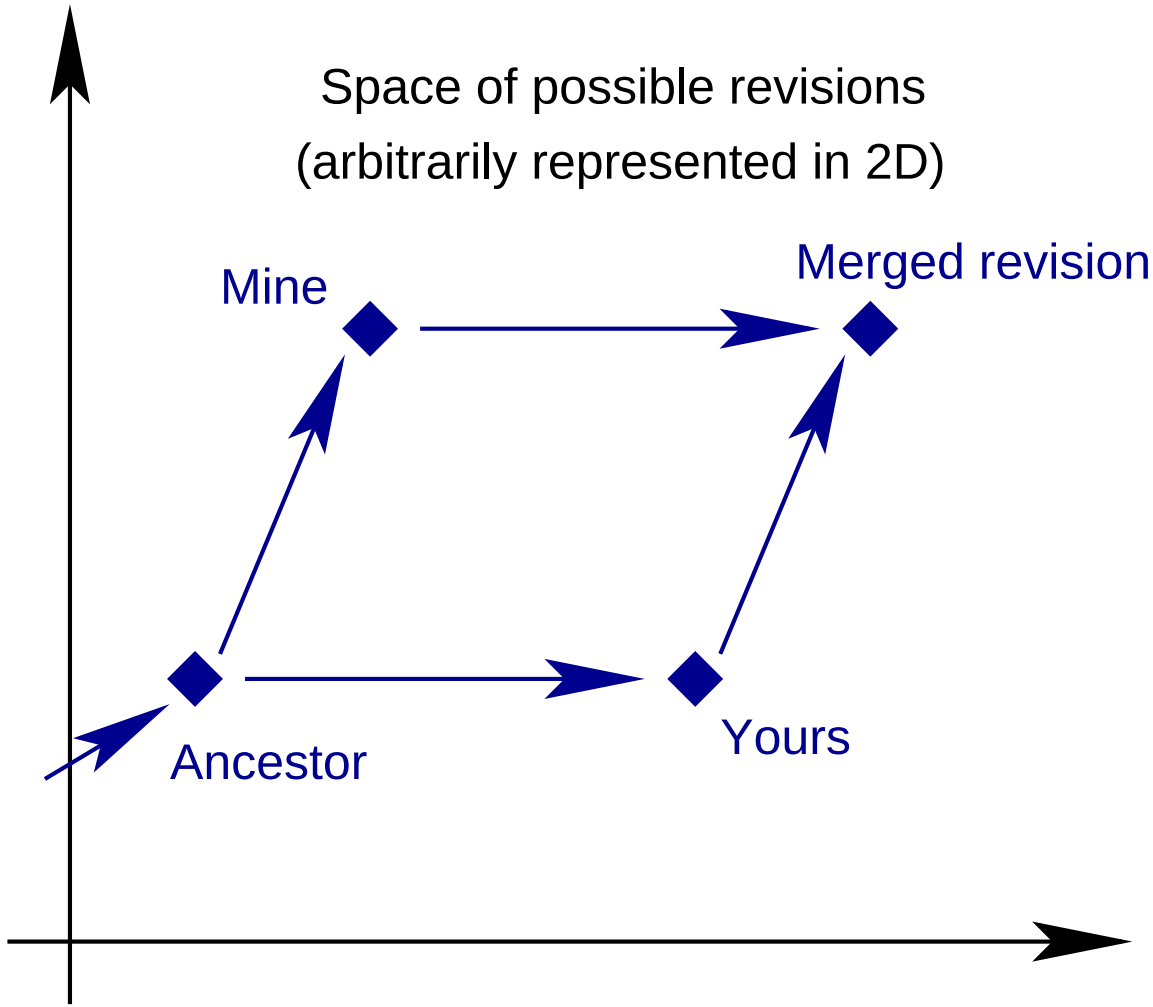
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Revision Control System: Basic Idea

- Keep track of history:
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  - Meta-data (user's name, date, descriptive message,...) recorded together with the state of the project.
- Use it for merging/collaborative development.
  - Each user works on its own copy,
  - User explicitly "takes" modifications from others when (s)he wants.

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- (Optional) notion of branch:
  - Set of revisions recorded, but not visible in mainline,
  - Can be merged into mainline when ready.

Outline

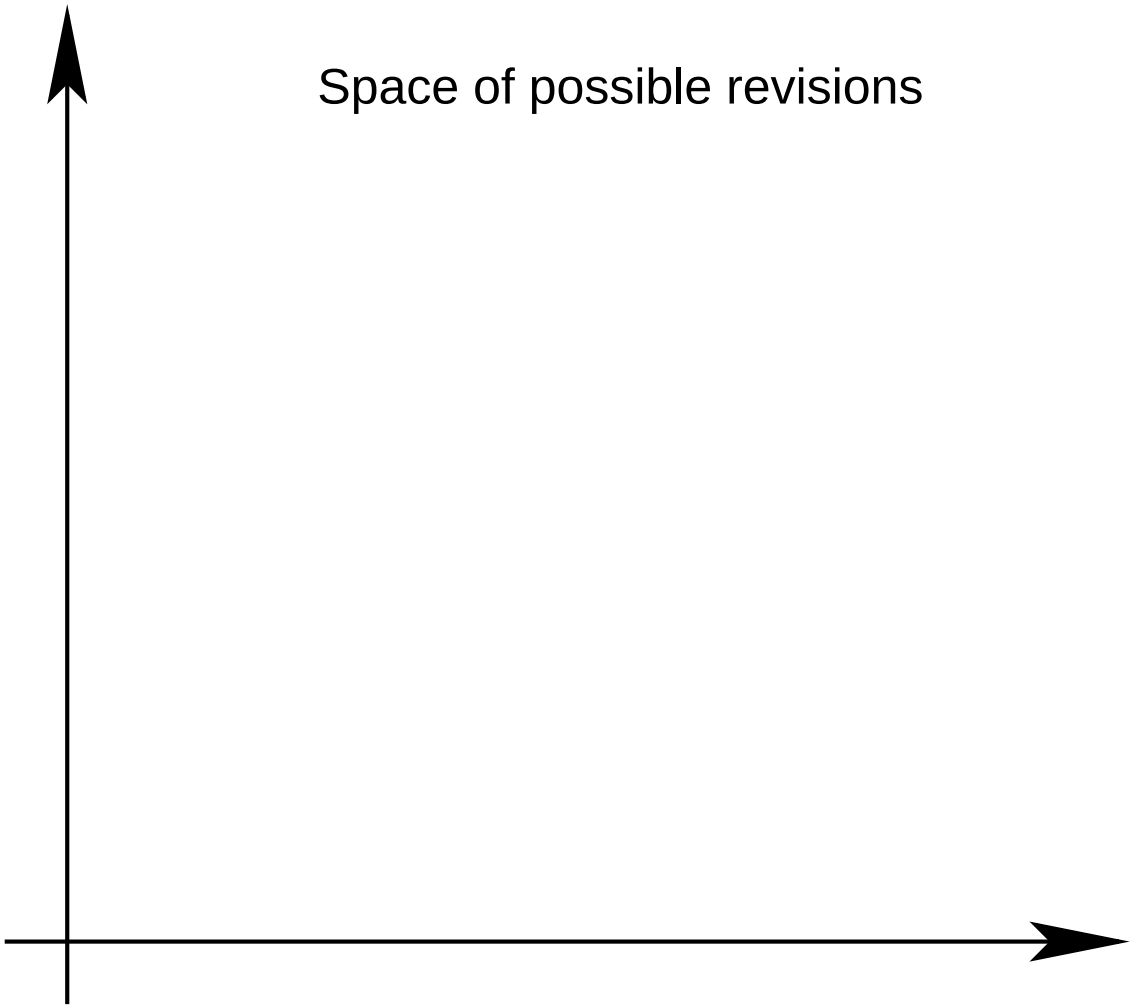
CVS: The Centralized Approach

- Configuration:
  - 1 repository (contains all about the history of the project)
  - 1 working copy per user (contains only the files of the project)
- Basic operations:
  - `checkout`: get a new working copy
  - `update`: update the working copy to include new revisions in the repository
  - `commit`: record a new revision in the repository

CVS: Example

- Start working on a project:
  ```
  $ cvs checkout project
  $ cd project
  ```
- Work on it:
  ```
  $ vi foo.c       # or whatever
  ```
- See if other users did something, and if so, get their modifications:
  ```
  $ cvs update
  ```
- Review local changes:
  ```
  $ cvs diff
  ```
- Record local changes in the repository (make it visible to others):
  ```
  $ cvs commit -m "Fixed incorrect Hello message"
  ```

Commit/Update Approach



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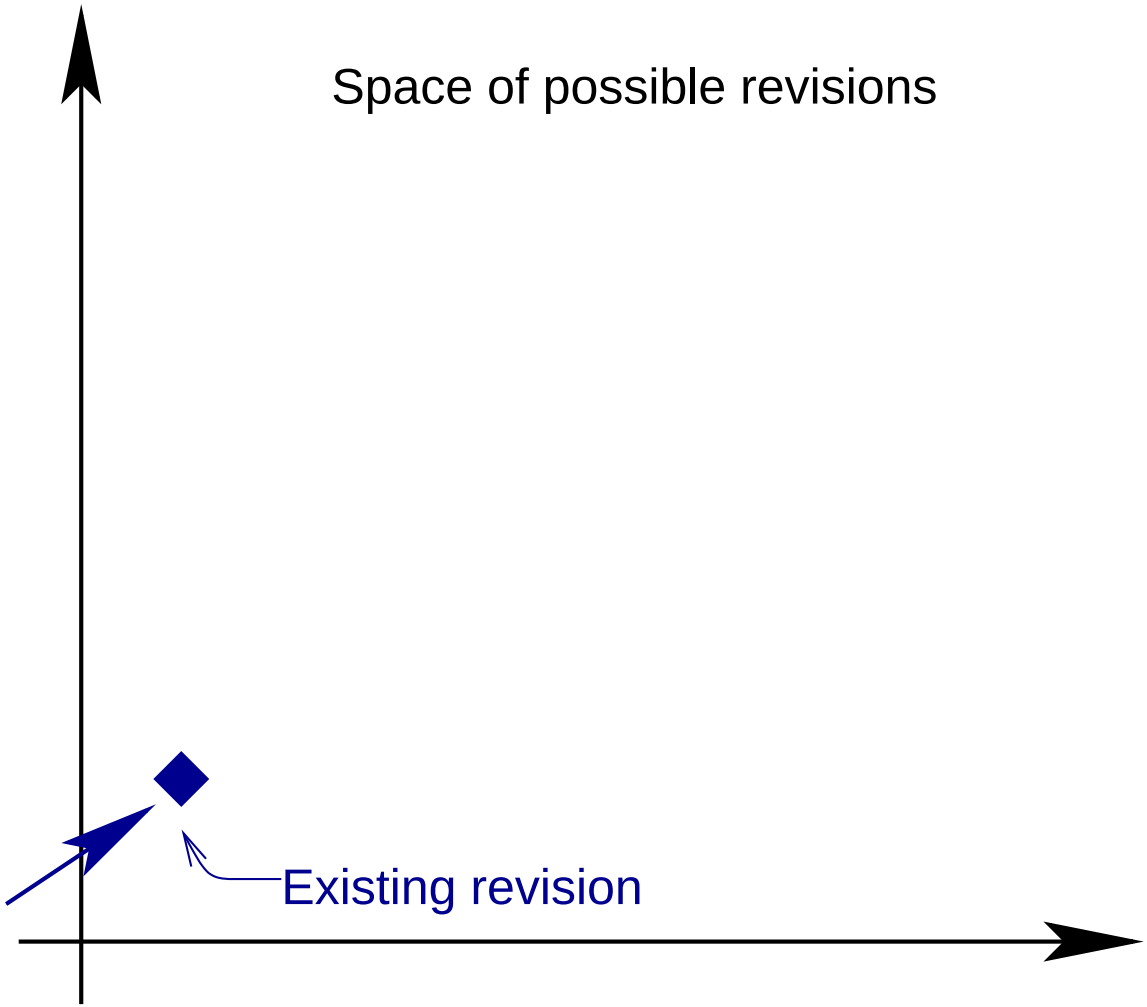

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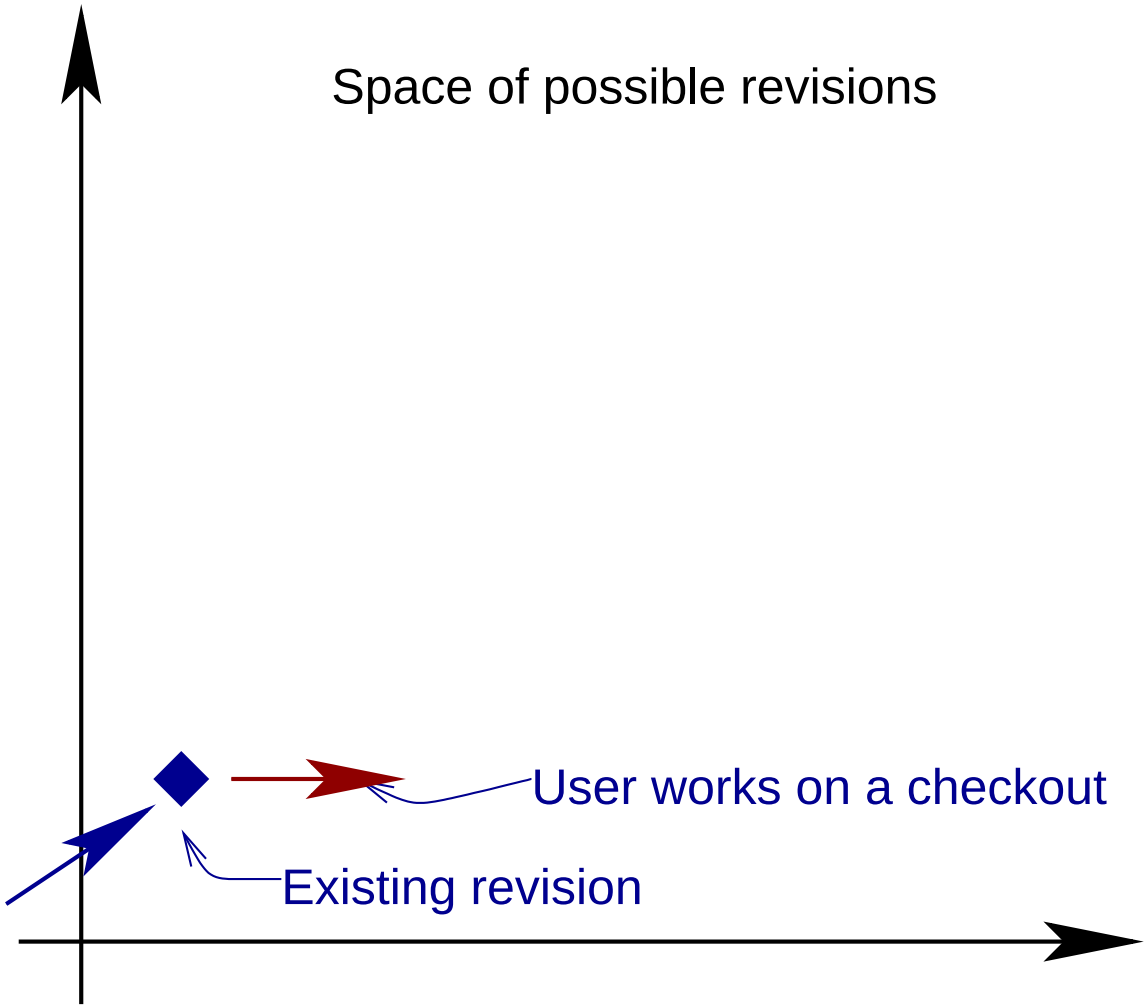

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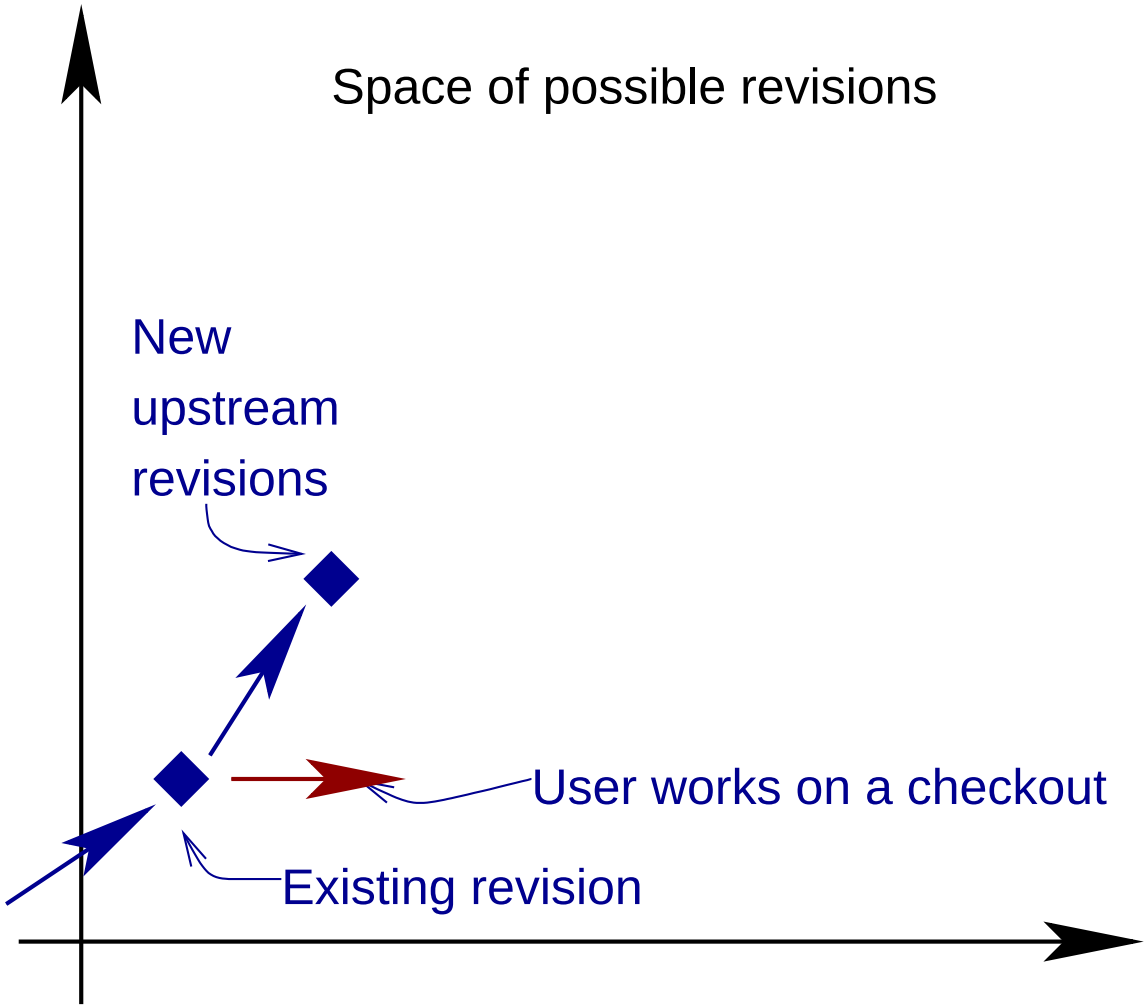

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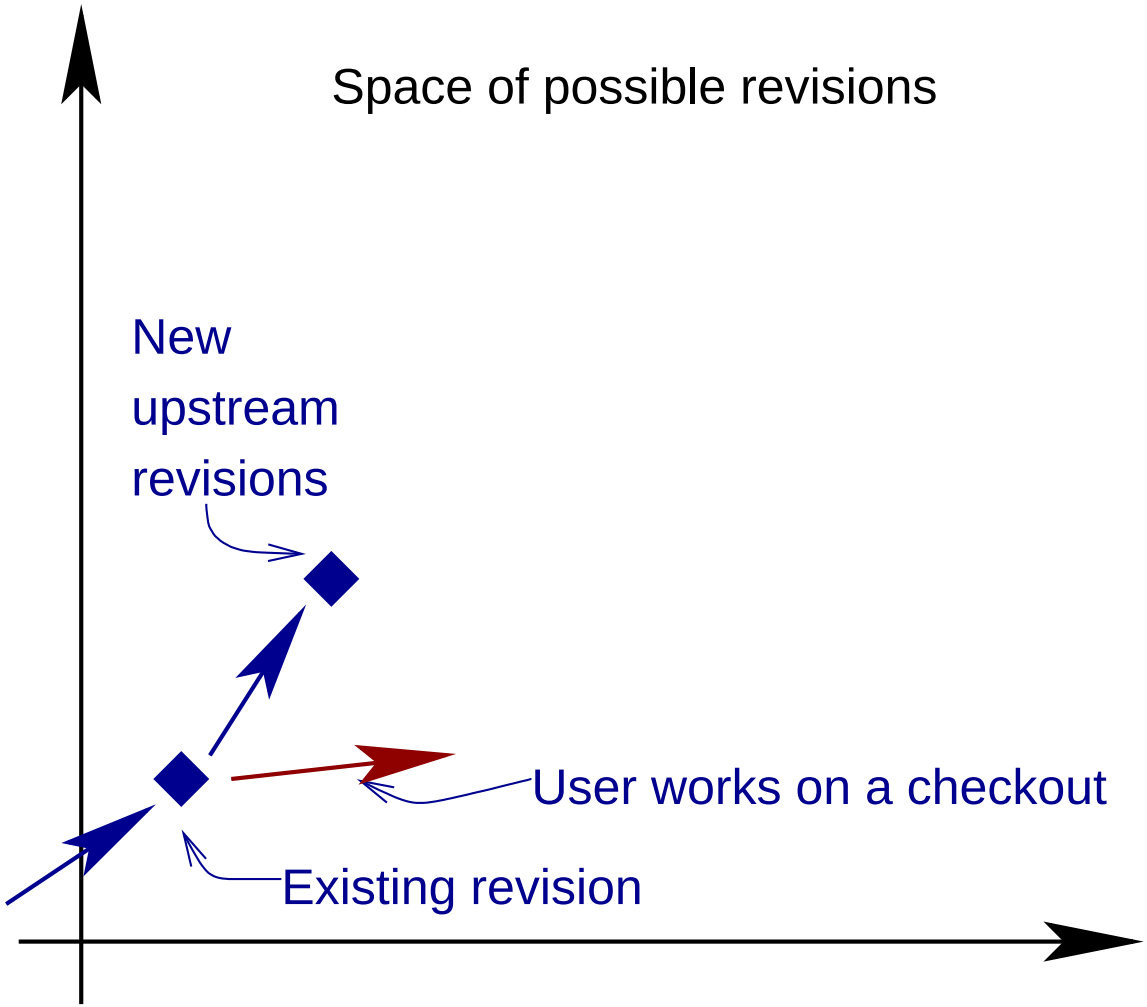

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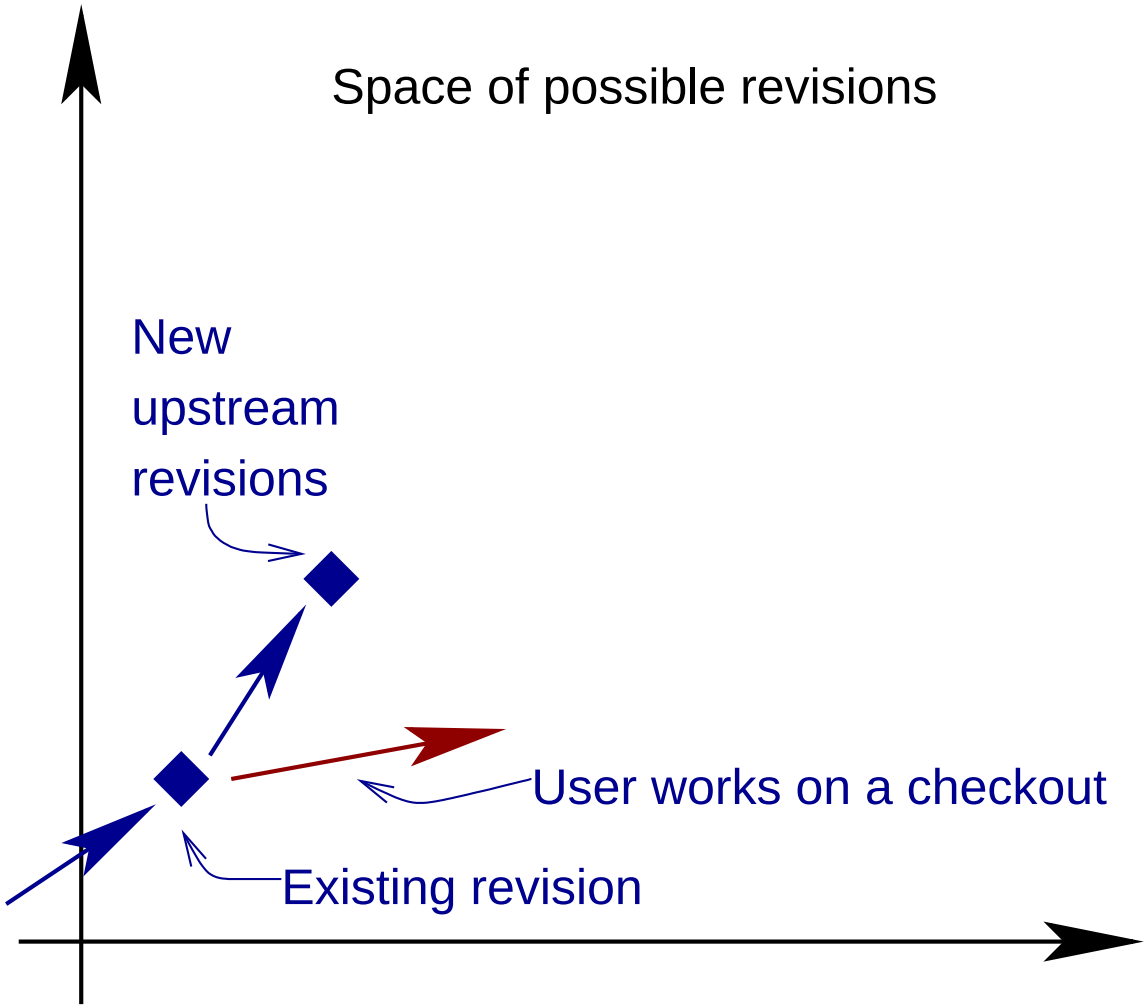

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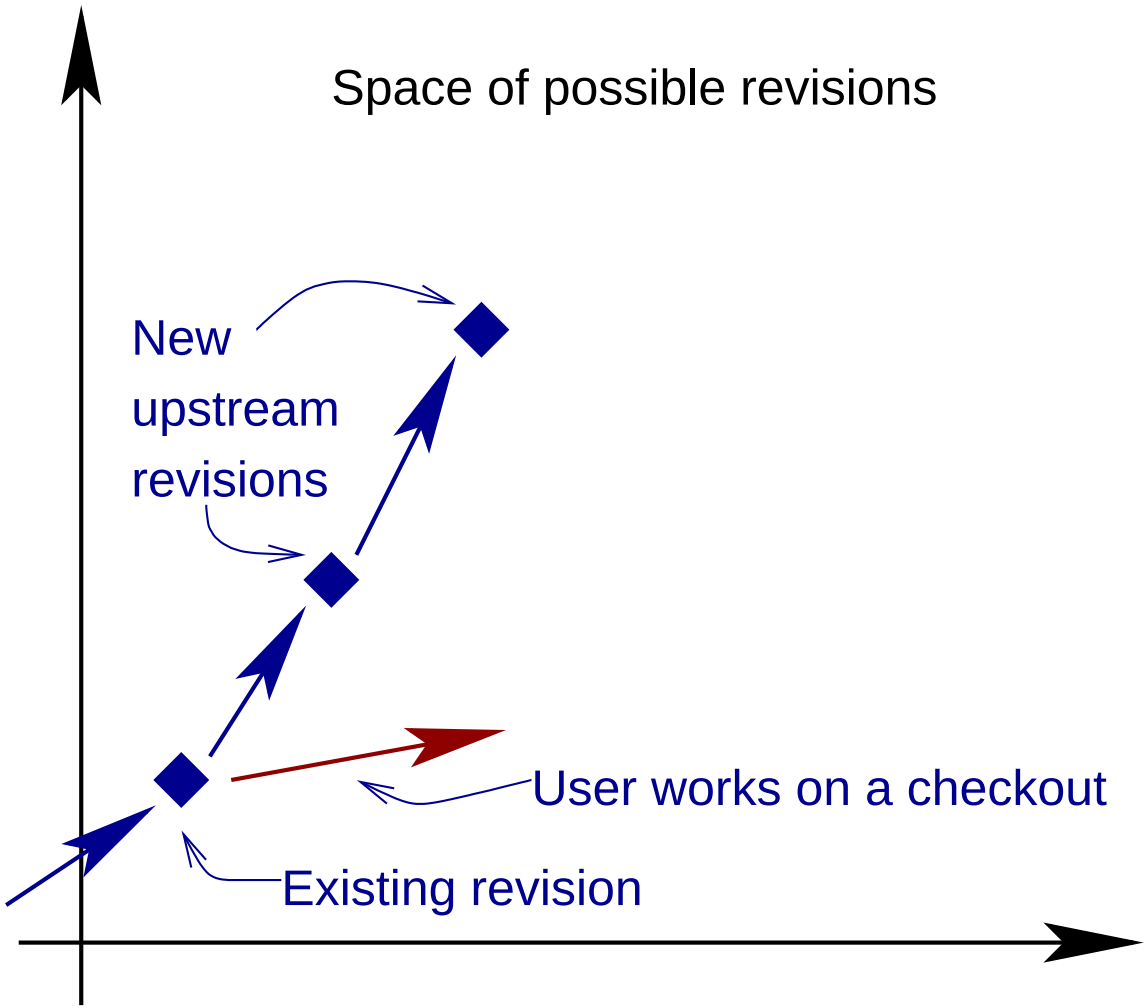

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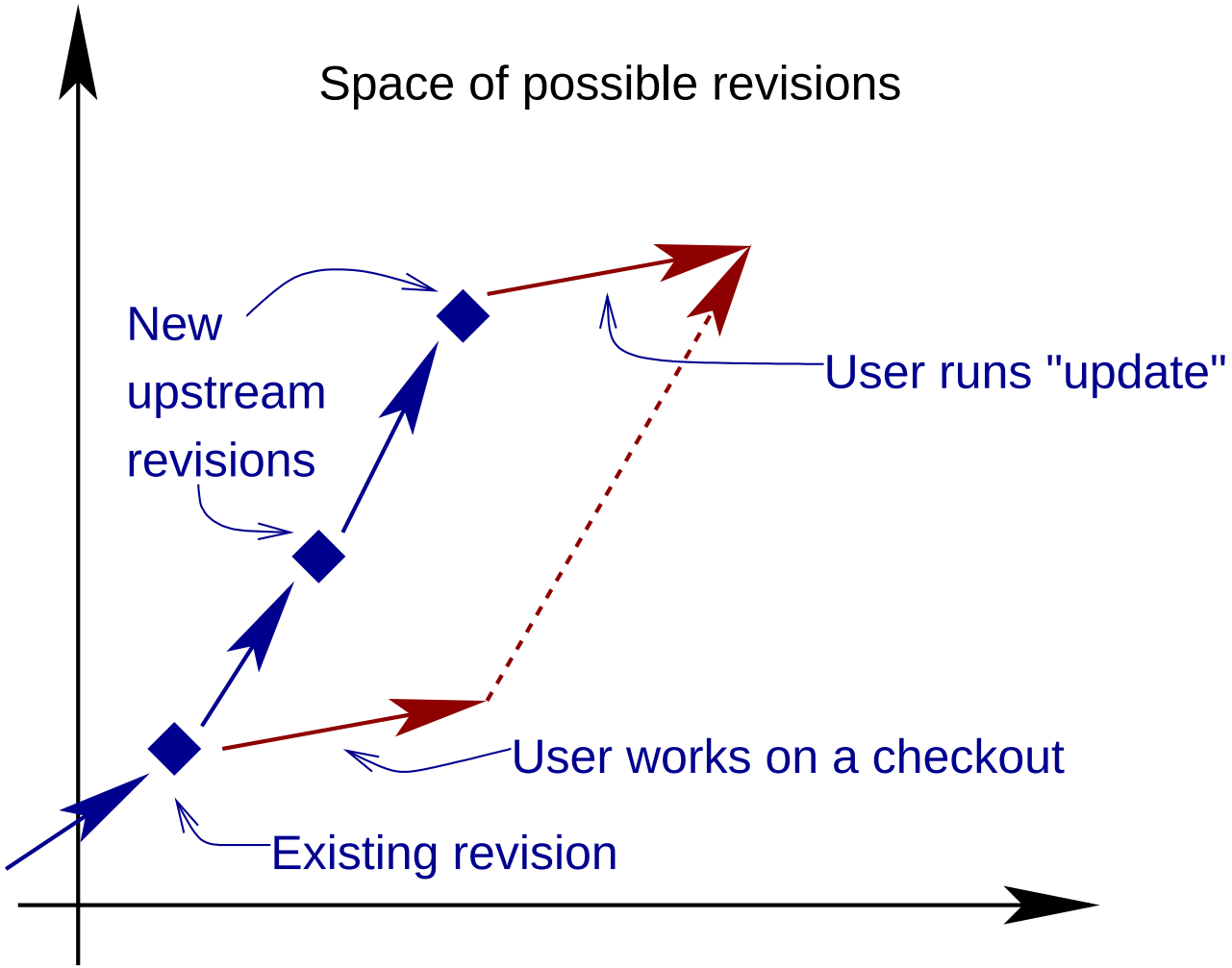

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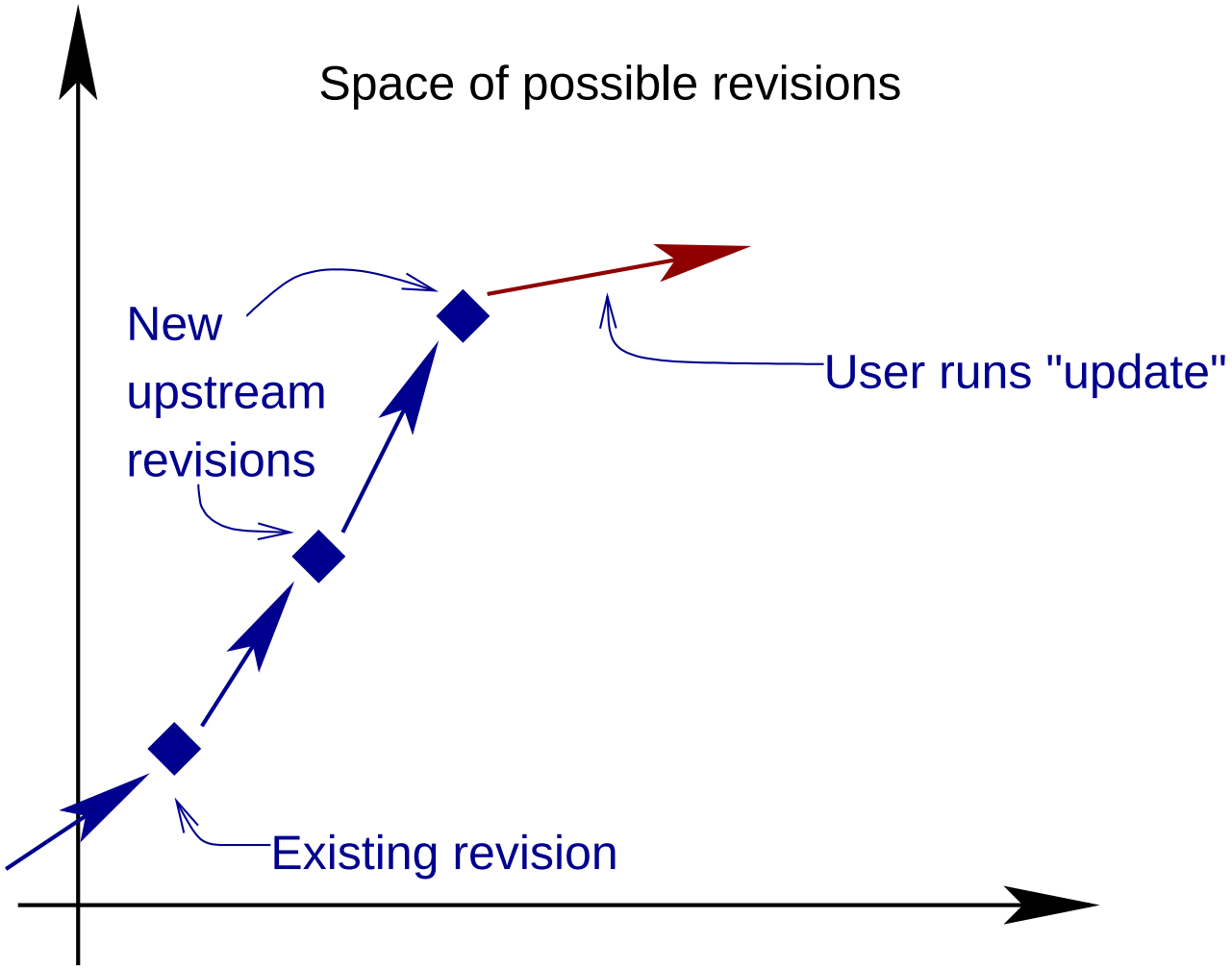

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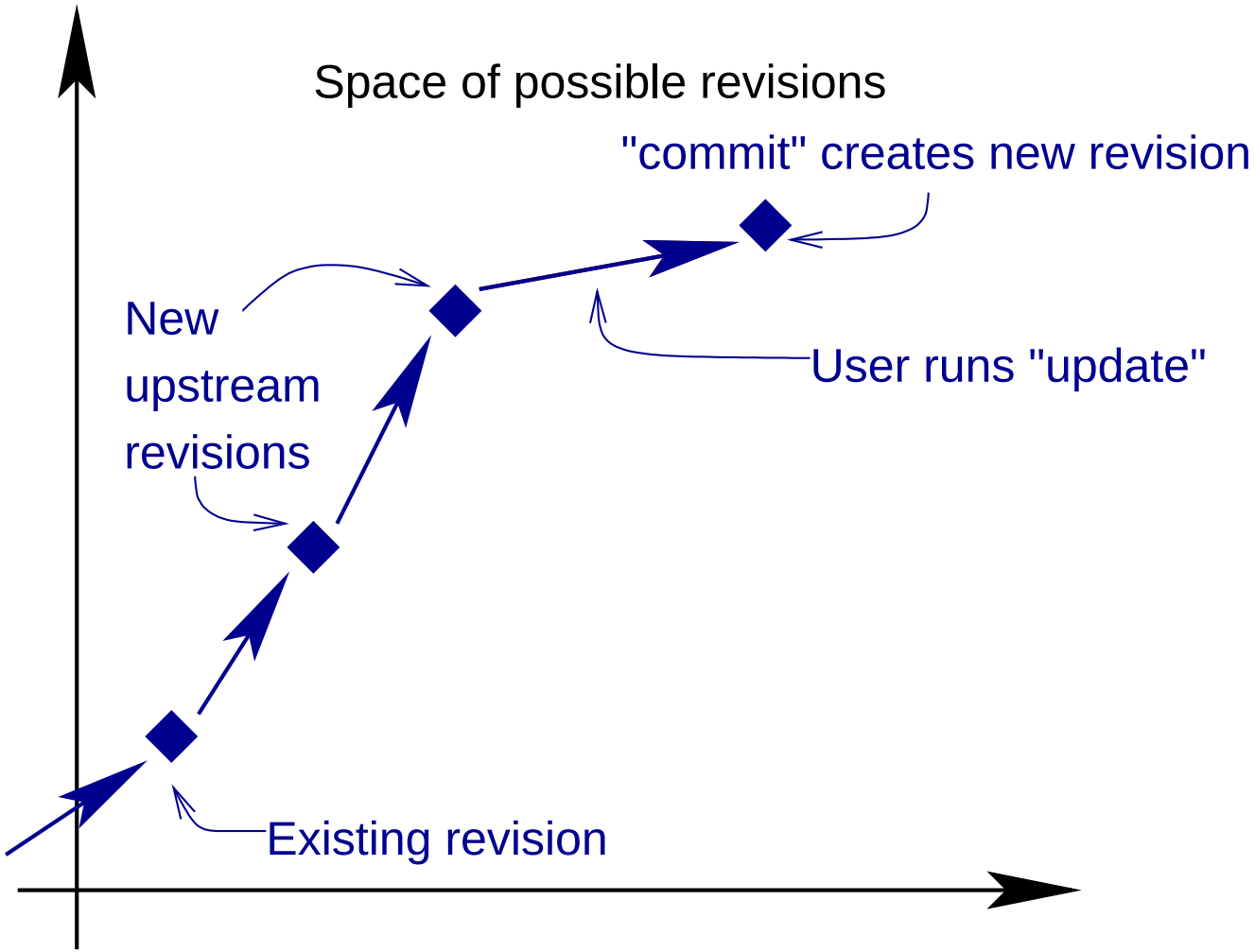

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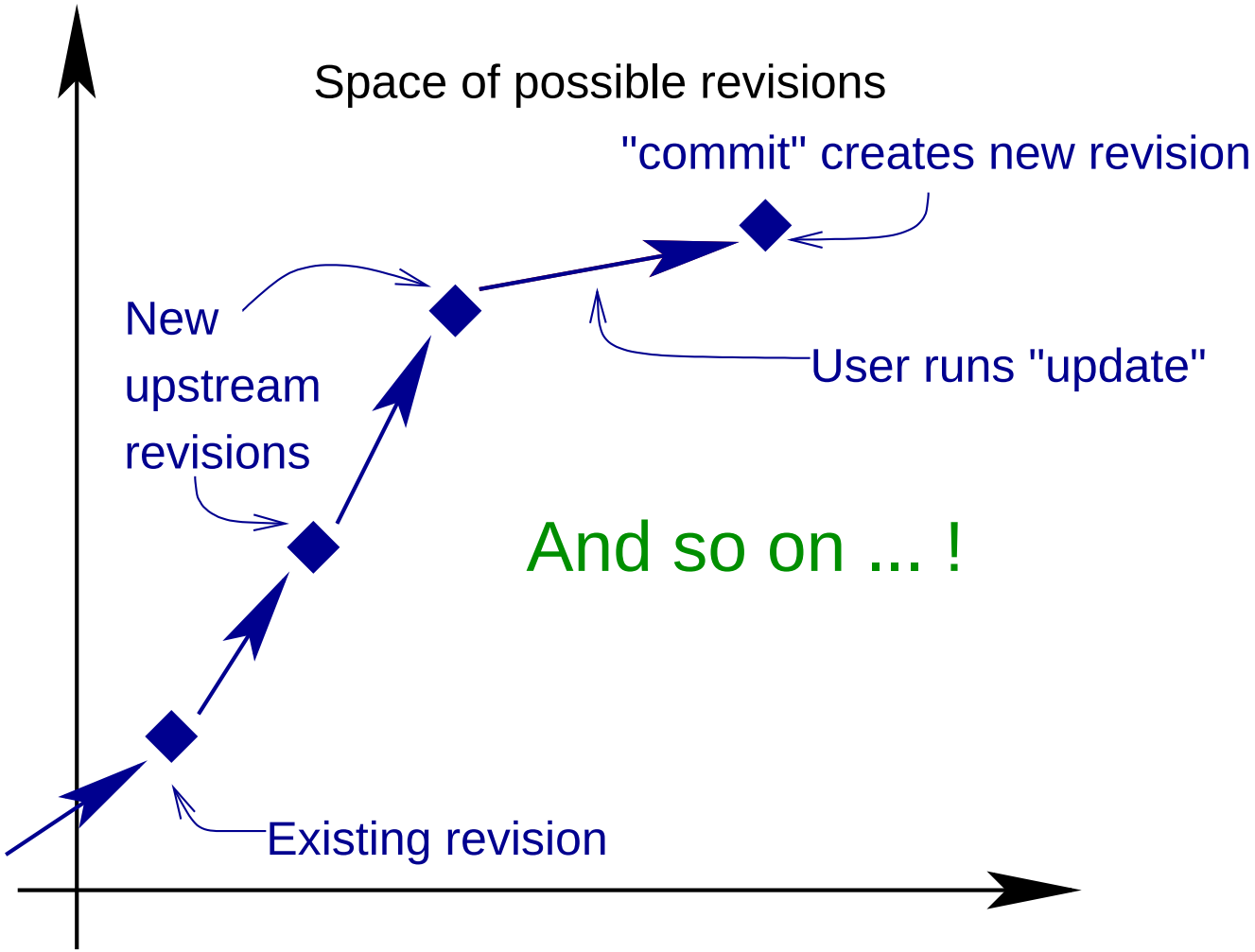

Conflicts

- When several users change the same line of code concurrently,
- Impossible for the tool to guess which version to take,
- $\Rightarrow$ CVS leaves both versions with explicit markers, user resolves manually.
- Merge tools (Emacs's `smerge-mode`, ...) can help.

Conflicts: an Example

- Someone added "\n", someone else added "!":

```
#include <stdio.h>

int main () {
<<<<<<< hello.c
  printf("Hello\n");
=======
  printf("Hello!");
>>>>>>> 1.6

  return EXIT_SUCCESS;
}
```

CVS: Obvious Limitations

- File-based system. No easy way to get back to a consistant old revision.
- No management of rename (`remove` + `add`)
- Bad performances

Subversion: A Replacement for CVS

- Idea of subversion: drop-in replacement for CVS (could have been "CVS, version 2").
  - Atomic, tree-wide commits (commit is either successful or unsuccessful, but not *half*),
  - Rename management,
  - Optimized performances, some operations available offline.

Fix the obvious limitation, but no major change/innovation

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from Subversion's FAQ:

> *We aren't attempting to break new ground in SCM systems, nor are we attempting to imitate all the best features of every SCM system out there. We're trying to replace CVS. [...]*

Remaining Limitations

- Weak support for merging,
- Most operations can not be performed offline,
- No private branches
- Permission management:
  - Allowing anyone on earth to commit compromises the security,
  - Denying someone permission to commit means this user can not use most of the features
  - Constraint acceptable for private project, but painful for Free Software in particular.

Decentralized Revision Control Systems

- Idea: not just 1 central repository. Each user has his own repository.
- By default, operations (including `commit`) are done on the user's private branch.
- Users publish their repository, and request a merge.

Outline

Linux: A Project With Huge Needs in Version Control

- Not the biggest Open-Source project, but probably the most active,
- $\approx$ 10Mb of patch per month,
- $\approx$ 20,000 files, 280Mb of sources.
- Many branches:
  - Short life: work on a feature in a branch, request merge when ready.
  - Long life: things that are unlikely to get into the official kernel before some time (grsecurity, reiserfs4, SELinux in the past, ...)
  - Test, debug: a modification goes through several branches, is tested there, before getting into mainline
  - Distributor: Most distributions maintain a modified version of Linux

$\Rightarrow$ Centralized revision control is not manageable.

A bit of history

1991: Linus Torvalds starts writing Linux, using mostly CVS,

2002: Linux adopts BitKeeper, a proprietary decentralized version control system (available free of cost for Linux),

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2005: BitKeeper's free of cost license revoked. Linux has to migrate.

2005: Unsatisfied with the alternatives, Linus decides to start his own project, git.

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- 2005: BitKeeper's free of cost license revoked. Linux has to migrate.
- 2005: Unsatisfied with the alternatives, Linus decides to start his own project, git.
- 2007: Many young, but good projects for decentralized revision control: Git, Mercurial, Bazaar, Monotone, Darcs, ...
- 200?: Most likely, several projects will continue to compete, but I guess only 2 or 3 of the best will be widely adopted.

Outline

Git Concepts

Revision: State of a project at a point in time, with meta-information,

Repository: Set of revisions, with ancestry information,

Branch: Succession of revisions,

Working tree: The project itself (set of files, directories...).

Git basic idea

- Git manages a set of objects (revision, files, directories, ...),
- Each object is identified by its sha1 sum (e.g. d188b7e3a58ce5a6a437c01e7095e79cba550d52),
- Objects can point to each other.

Starting a Project

- Create a new project:
  `$ mkdir project` (or just use an existing one)
  `$ cd project`
  `$ git init`
- This creates a repository and a working tree in the same place.
  Try "`ls .git/`" to see what happened.

Create the First Revision

- Add files (git won't touch the files unless you explicitly add them):
  `$ git add .`
  or individually
  `$ git add file1; git add file2`
- Commit (record new revision):
  `$ git commit -m "descriptive message"`
  (if you don't provide `-m`, an editor will be opened to let you type your message)
- Unlike most version control systems, git ask you to "git add" files when you change them. Surprising, but indeed powerful.

Look at Your Own Changes

- Short summary: `git status`

```
$ git status # Changed but not updated:
#   (use "git add <file>..." to update what will be committed)
#
#       modified:   bar.c
#
# Untracked files:
#   (use "git add <file>..." to include in what will be committed)
#
#       foo.c
```

Look at Your Own Changes

- Short summary: `git status`
- Complete diff: `git diff`

```
$ git diff HEAD
diff --git a/foo.c b/foo.c
index d9bd708..a026613 100644
--- a/foo.c
+++ b/foo.c
@@ -1,5 +1,5 @@
 #include <stdio.h>

 int main() {
-        printf ("hello");
+        printf ("hello\n");
 }
```

Look at the History

- See the past revisions:

```
$ git log
commit 1d0ddc98025de7b159ac319a6e3d691fe5cf4c03
Author: Matthieu Moy <Matthieu.Moy@imag.fr>
Date:   Tue Oct 9 15:35:39 2007 +0200

    Fixed a bug

commit bf45d2100fe662b2afb8e48eb40d4bf5a7dbc2fe
Author: Matthieu Moy <Matthieu.Moy@imag.fr>
Date:   Tue Oct 9 15:35:24 2007 +0200

    initial revision
```

Publish your repository

- Up to now, your repository is just on your disk, no one else sees it,
- Publish you branch:
  `$ git push ssh://some-host.com/project-upstream` (git needs to be installed on the remote host, but no daemon needed)
- Other people can now clone it:
  `$ git clone http://some-host.com/project-upstream`
  (assuming the sftp location and http location are the same on `some-host.com`).

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- Publish it and request a merge:
  ```
  $ git push ssh://another-host.com/your/project
  $ mail -s "please, merge ..."
  ```

Merging

- Two use cases:
  - As a contributor, you started working on a feature in your own repository, but you want to follow upstream development.
  - Your feature is completed, upstream wants to merge it.
- Symetry in both use-cases,
- Successive merge possible,
- Git keeps track of merge history. It knows what you miss, and what has already been merged.

Merging

- Merge the changes into the local repository:

```
$ git pull ../bar/
```

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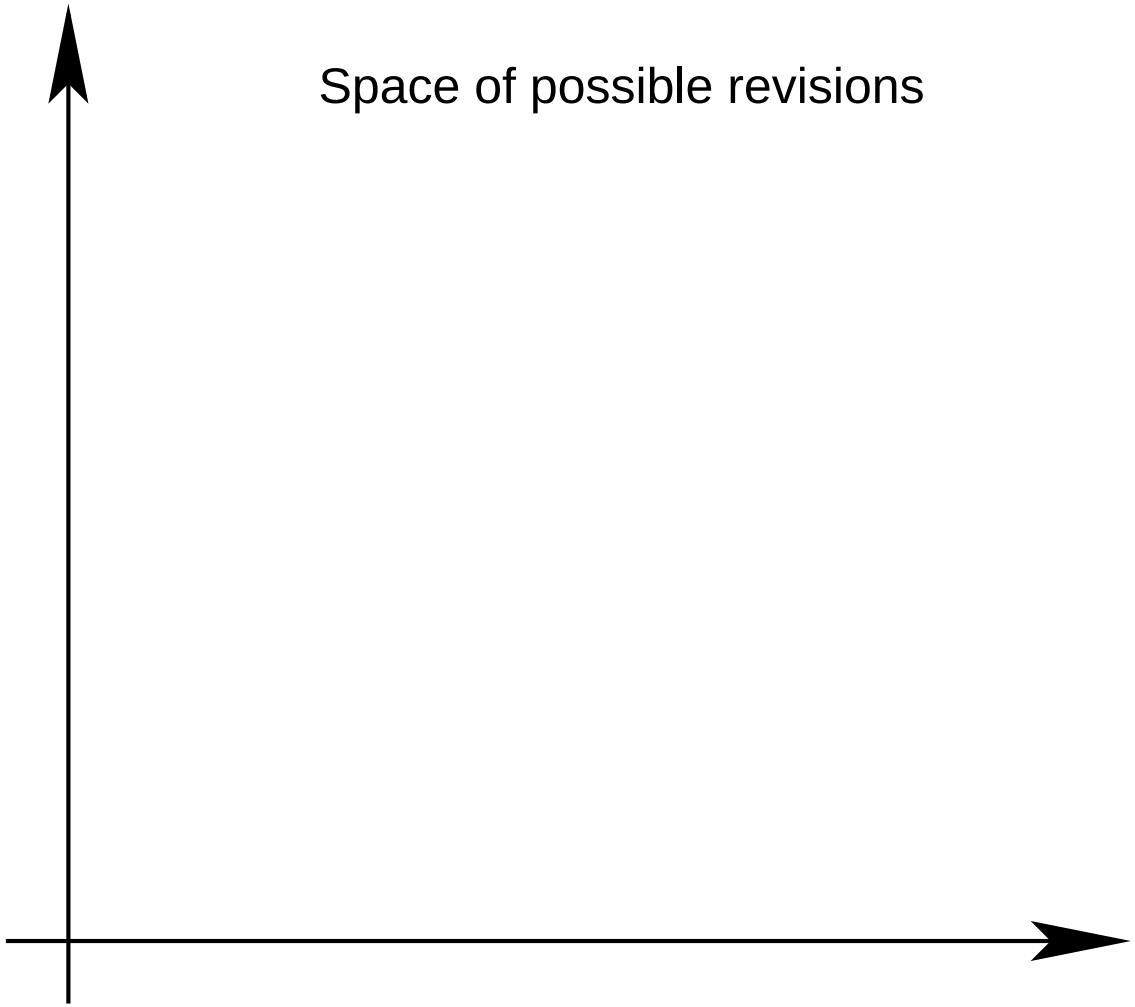
- Merge Commit: Unless you're merging a branch which you are a direct ancestor of, git will create a new commit, corresponding to the merge.

Merging



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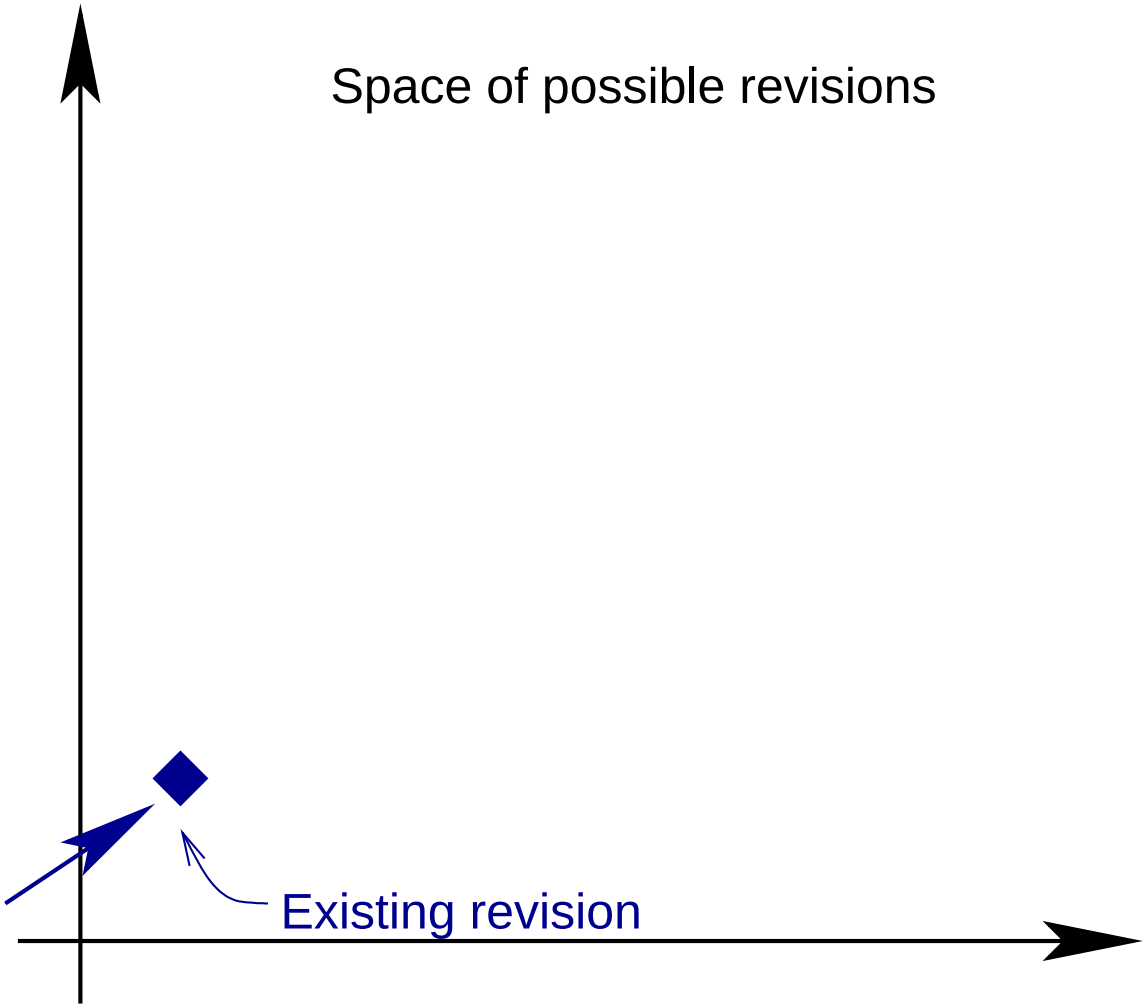

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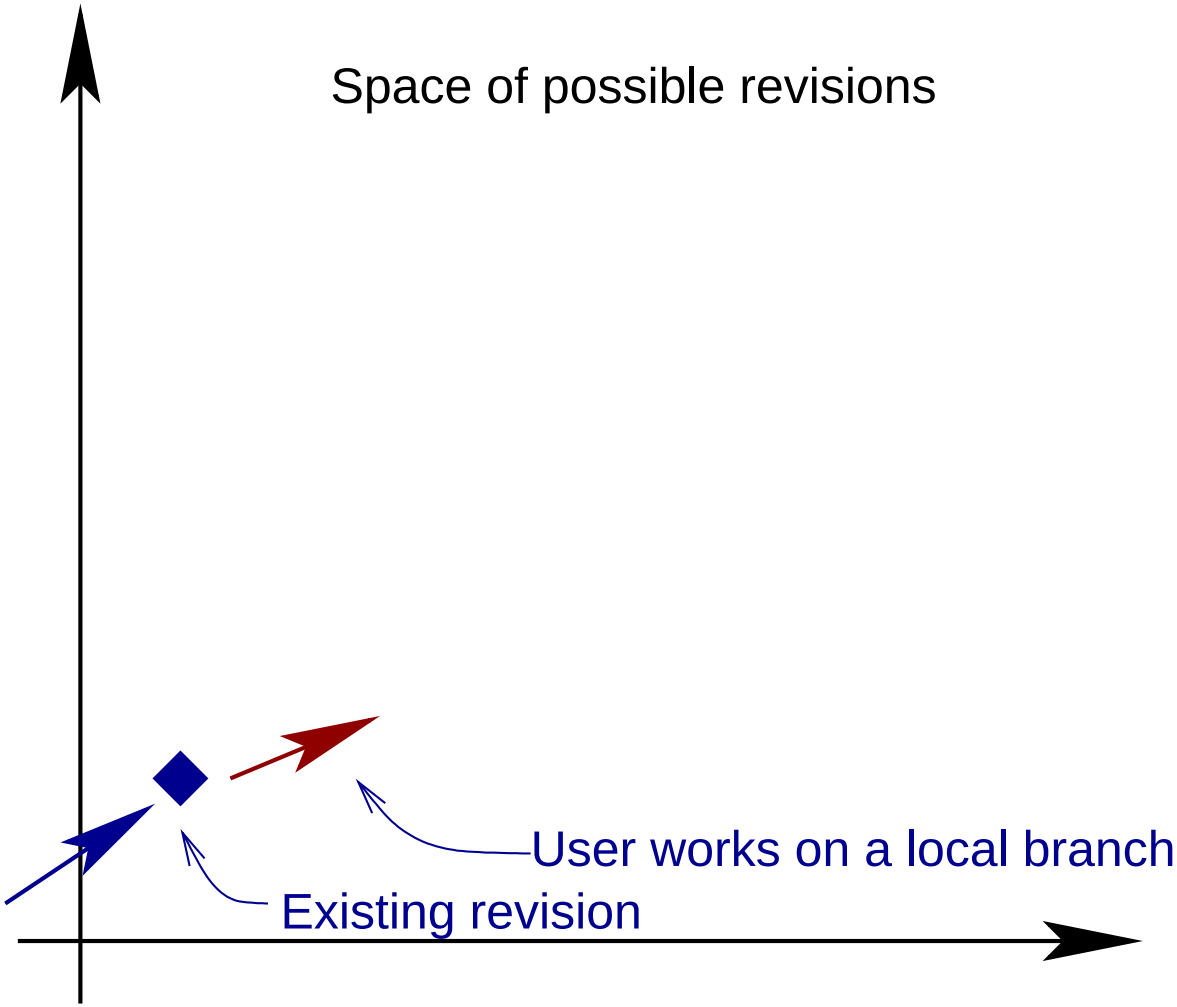
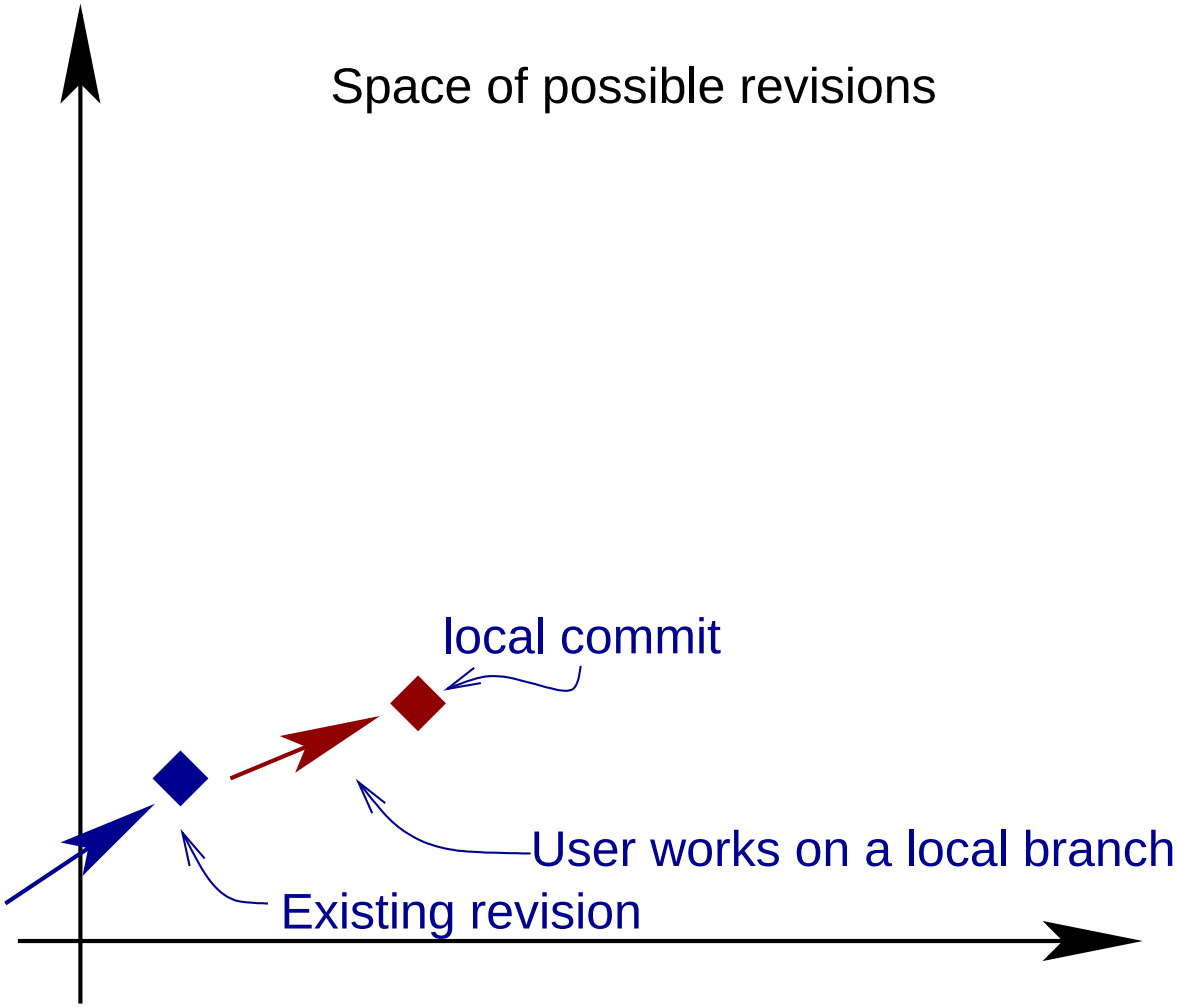
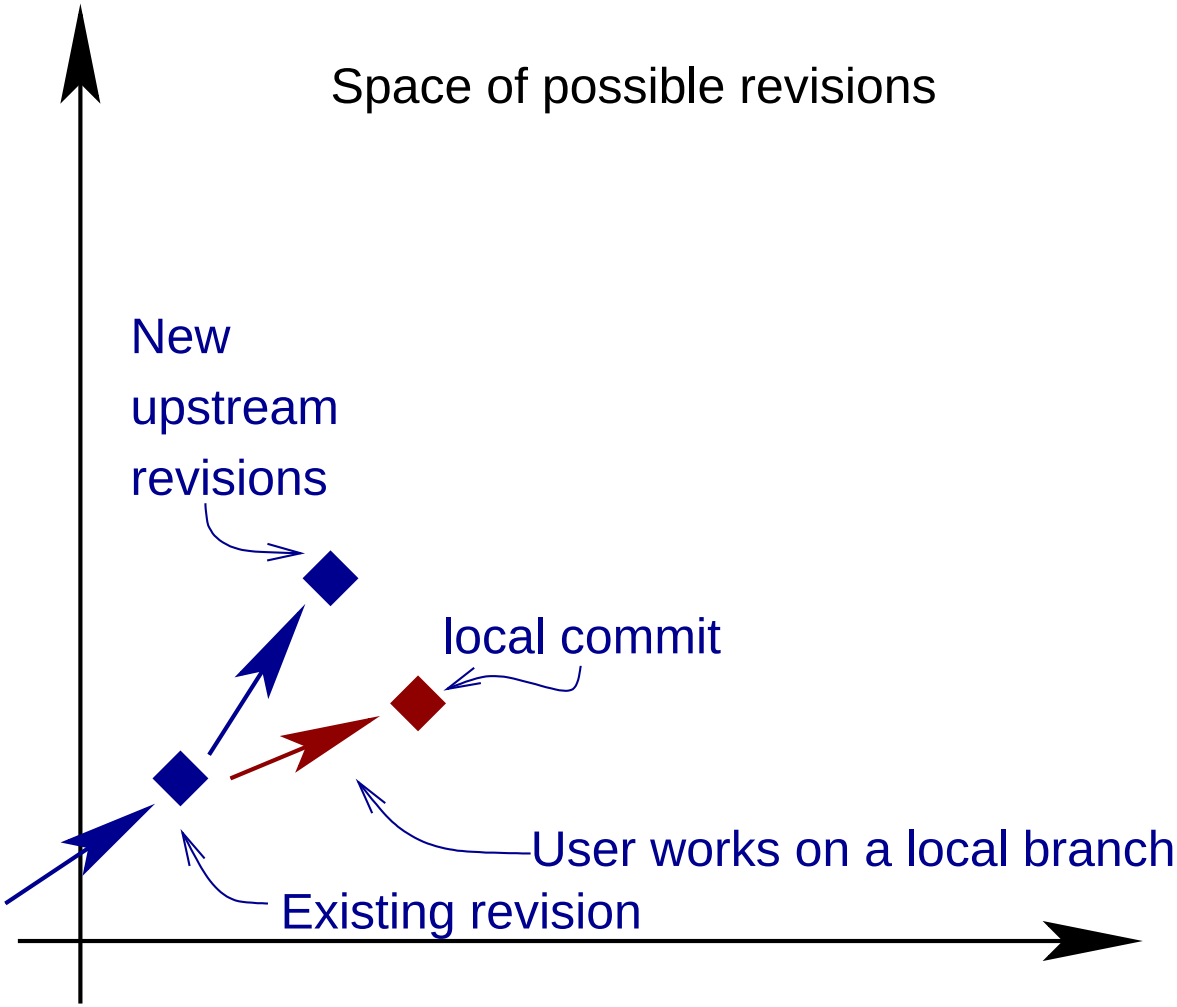

Space of possible revisions
User works on a local branch
Existing revision

Merging


Space of possible revisions
local commit
User works on a local branch
Existing revision

Merging


Space of possible revisions
New
upstream
revisions
local commit
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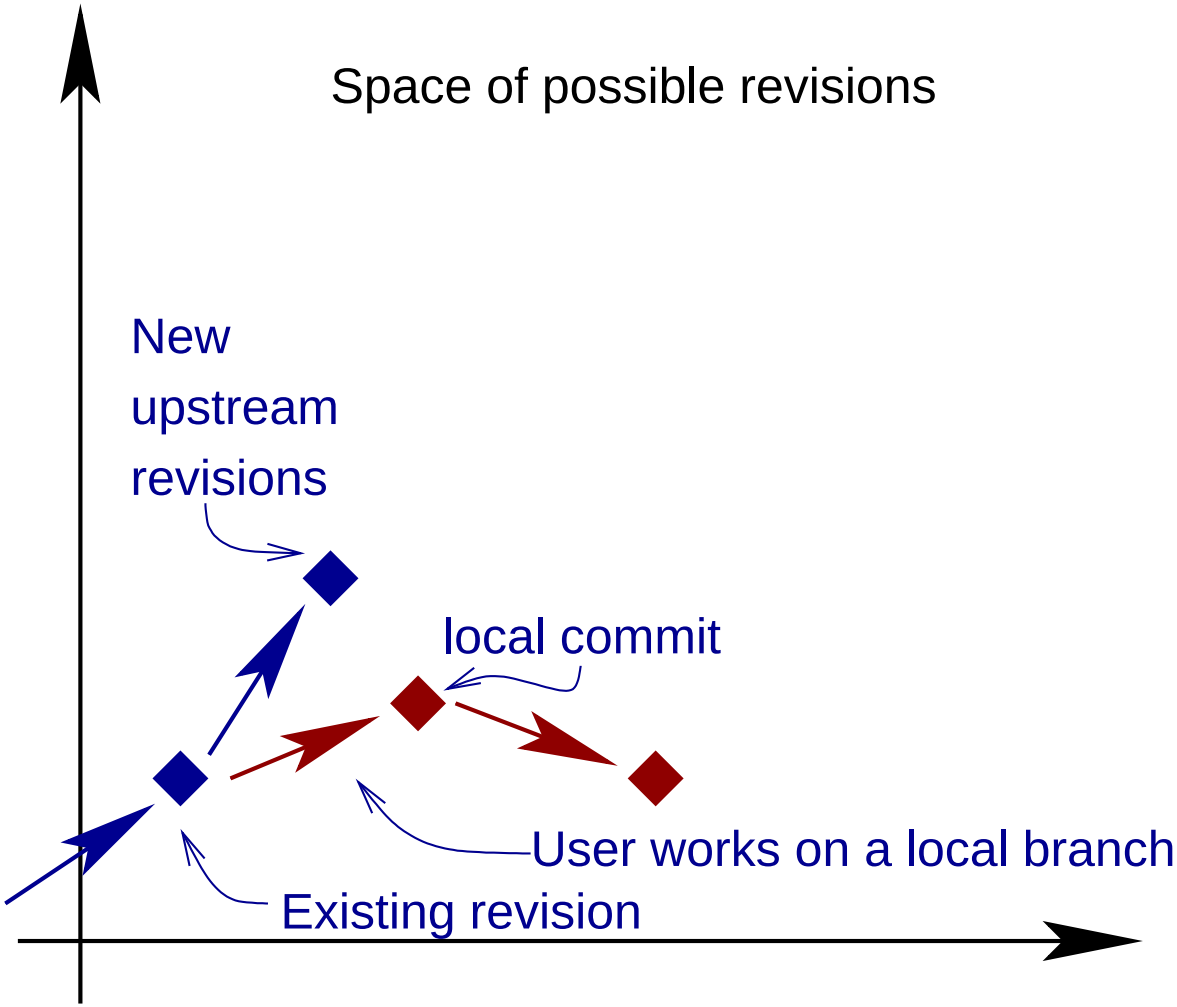
Existing revision

Merging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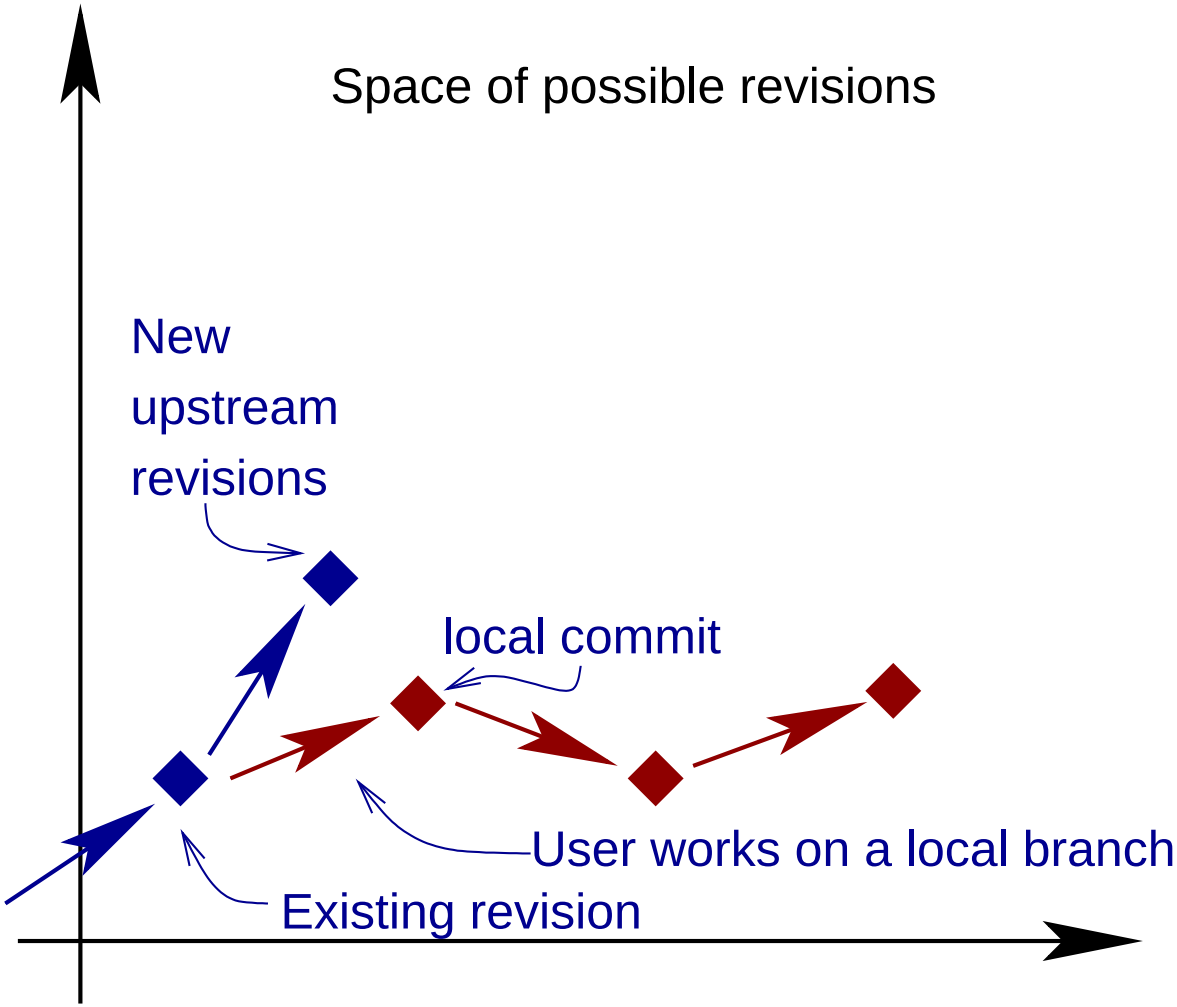
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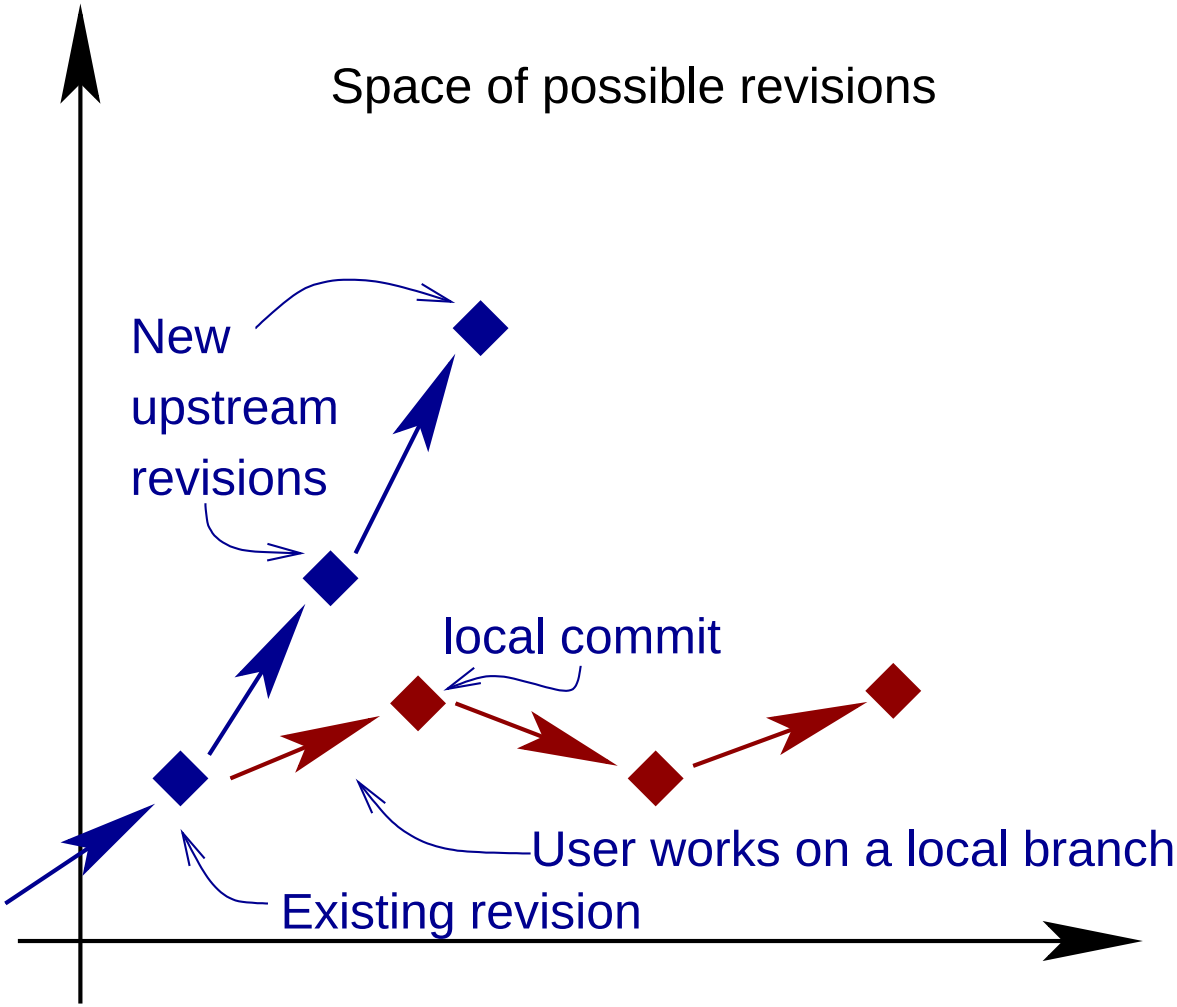
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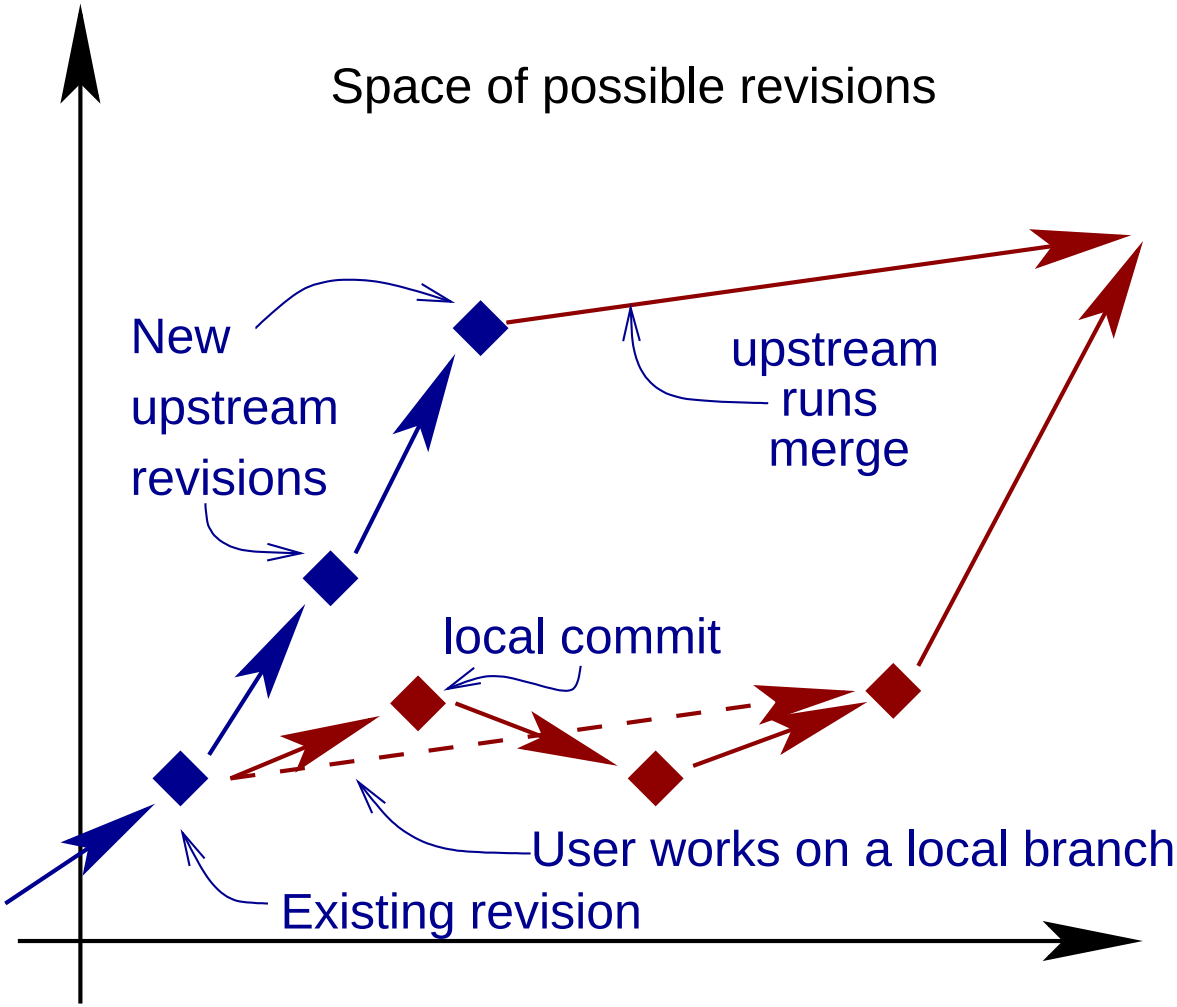
Space of possible revisions
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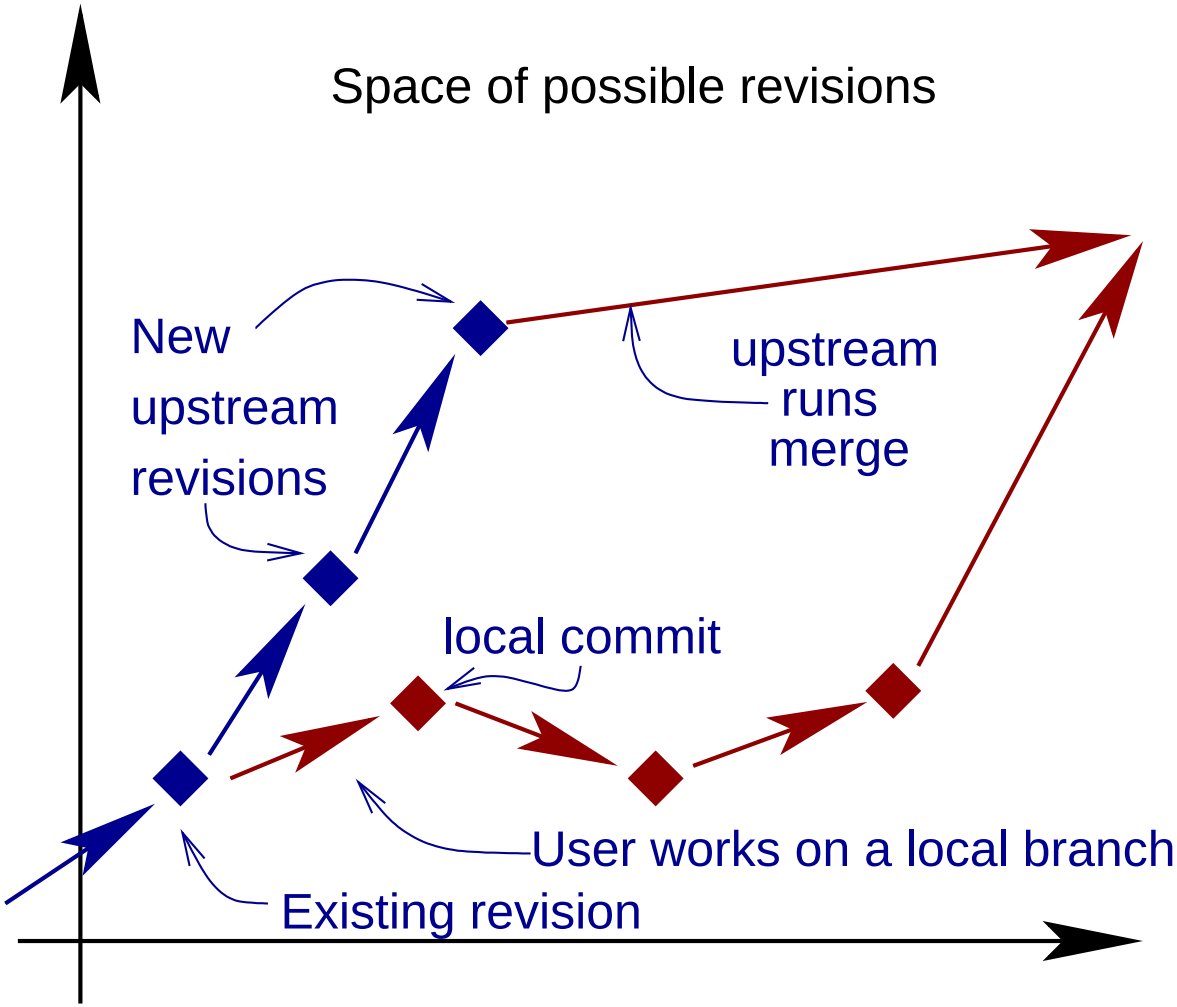
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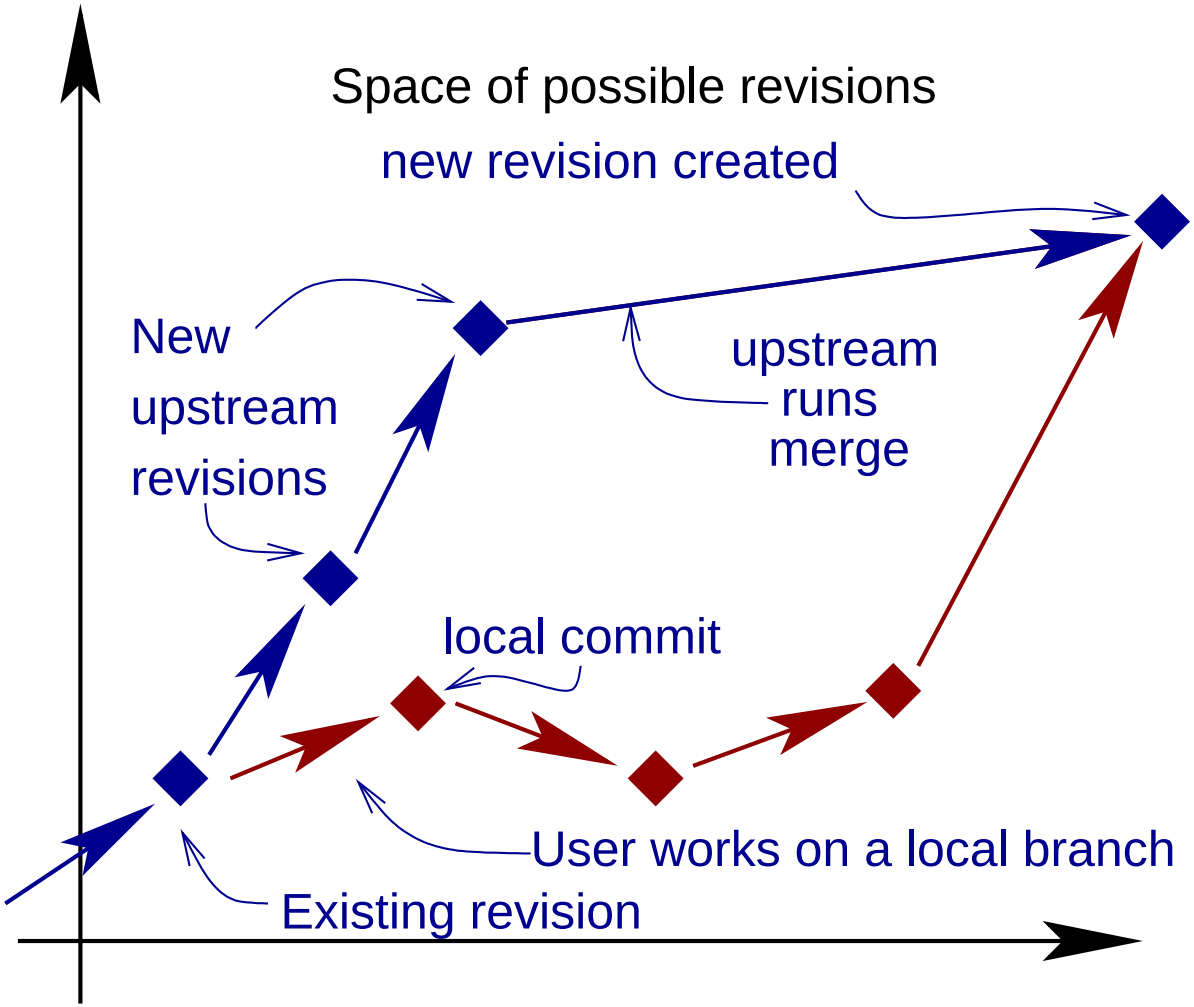
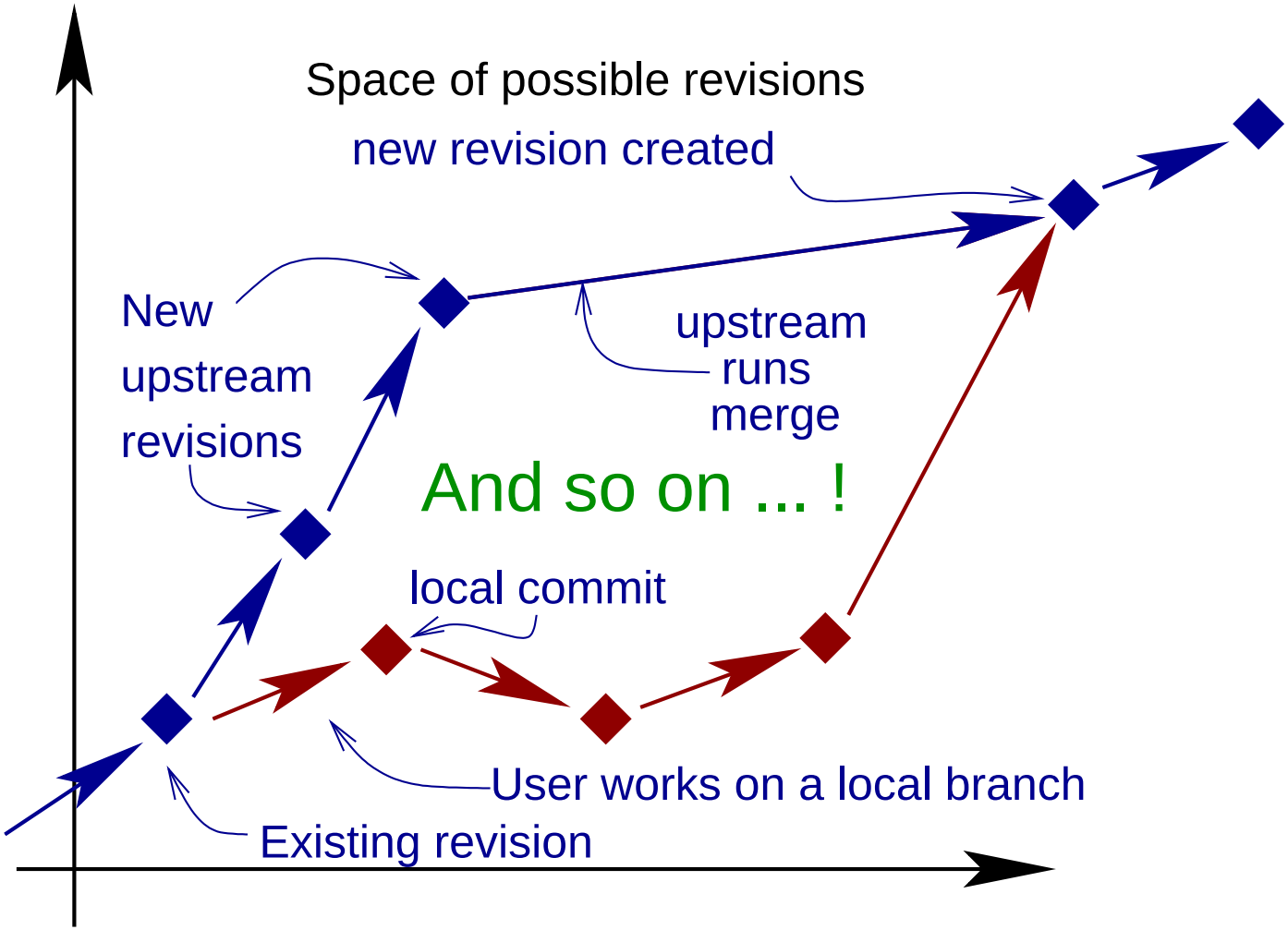
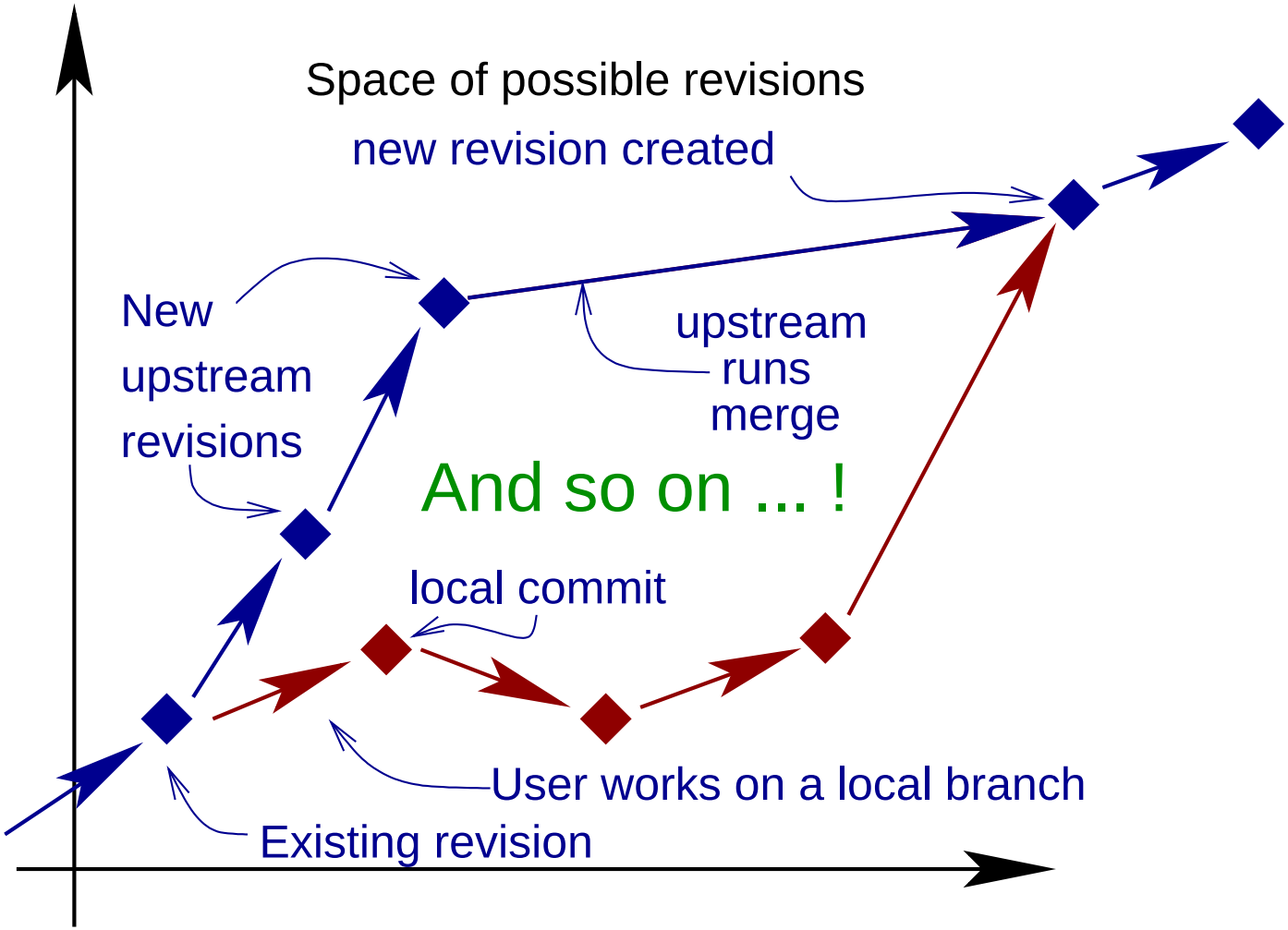

Space of possible revisions
new revision created
New
upstream
revisions
upstream
runs
merge
local commit
User works on a local branch
Existing revision

Merging


Space of possible revisions
new revision created
New
upstream
revisions
upstream
runs
merge
And so on ... !
local commit
User works on a local branch
Existing revision

Merging



Resulting revision history is a DAG

Other Features of Interest

Git index: A staging area to prepare your commits. Probably the most powerful way to make partial commits.

Tags: Give a name to a revision (e.g. "release-1.0")

Local branches: Multiple branches within the same repository,

Pack files: The default storage format for git is disk-inefficient. Run "`git gc`" occasionally, and you'll get the most compact format of the VCS I know about.

Subversion interface: `git-svn` allows you to use git on a subversion repository.

Git daemon: serve Git repository much faster than plain HTTP.

Outline

Benefit of Version Control

- Working alone:
  - Possibility to revert to a previous revision,
  - Makes it easy to review your own code (before committing),
  - Synchronization of multiple machines.
- Collaborative development:
  - One can work without disturbing others,
  - Merge is automated.

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"Text editing without version control is like sky diving without a parachute!"

Benefit of *Decentralized* Version Control

- Easy branch/merge,
- Simplifies permission management
  (no need to give any permission to other users),
- Disconnected operation
  (useful for laptop users in particular).
- Private branches.

Other Decentralized Version Control Systems

Monotone: A clever system based on hashes (SHA1). Inspired git a lot.
http://venge.net/monotone/

Bazaar: Designed for ease of use and flexibility. Used and developed by Canonical (Ubuntu),
http://bazaar-vcs.org/

Mercurial: Close in concepts and performance to git. Written in python, with a plugin system.
http://www.selenic.com/mercurial/

Darcs: Based on a powerful patch theory. Was the first system to have a really simple user-interface.
http://abridgegame.org/darcs/

SVK: Distributed Version Control built on top of Subversion.
http://svk.bestpractical.com/

Emacs Users

[Warning: Self advertisement]

- Most version control systems have an Emacs integration.
- Check out DVC: http://download.gna.org/dvc/

Version Control and Backups

- Version Control is a good complement for backups
- But your repository should be backed-up/replicated !
  (many users lost their data and their revision history at the same time with a disk crash)
- Usually:
  - Version Control = User side (manual creation of project, manual add of source files, manual commits, . . .)
  - Backup = System Administrator side (cron job, backing up everything)

Last Word on Backups

- Don't trust your hard disk,
- Don't trust a CD (too short life),
- Don't trust yourself,
- Don't trust Anything!
- REPLICATE!!!
  - Multiple machines for normal work
  - Multiple sites for important work (are you ready to loose you thesis if your house or lab burns?)

Learn More

Git: http://git.or.cz/

Git Tutorial: http://www.kernel.org/pub/software/scm/git/docs/tutorial.html

Version Control: http://en.wikipedia.org/wiki/Revision_control

This presentation:
http://www-verimag.imag.fr/~moy/slides/git/