Version Control Systems

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Lecture 13

B3B36PRG – C Programming Language

Overview of the Lecture

- Part 1 – Version Control Systems

  Introduction and Terminology

  Version Control Systems

  Git

  SVN - Subversion

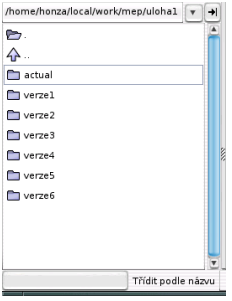
  Versioning

Part I

Part 1 – Version Control Systems (VCSs)

What is Version Control?

- Working on a project or an assignment, we can tend to "backup" our early achievements mostly "just for sure".
  - `hw01`
  - `hw01.backup`
  - `hw01.old`
  - `hw01.old2`
  - `hw01.old3`



- We may try a new approach, e.g., for optional assignment, but we would like to preserve the previous (working) approach.
- We may also want to backup the files to avoid file/work lost in a case of hard/solid drive failure. *We need to save it to a reliable medium.*
- Finally, we need a way how to distribute and communicate our changes within our development team.

Version Control System

- Version Control System (VCS) is a tool (or set of tools) providing **management of changes to files over time**.
  - Uniquely identified changes (**what**).
  - Time stamps of the changes (**when**).
  - Author of the changes (**who**).
- VCS can be
  - Manual (by hand), e.g., "save as."
    - Creating multiple copies of files and changes documented in an annotation.
    - Backups of the file systems (e.g., snapshots).
    - Files shared between team members.
  - Automated version control
    - System or application manages changes.
    - Version tracking is managed internally by the system or application.
    - It may provide further support for collaboration (team development).

Benefits of Version Control System (VCS)

- VCS provides numerous benefits for both working environment (individual and team).
- Individual benefits:
  - Backups with tracking changes;
  - **Tagging** – marking the particular version in time;
  - **Branching** – multiple versions;
  - **Tracking** changes;
  - **Revert** (undo) changes.
- Team benefits
  - Working on the same code sources in a team of several developers;
  - **Merging** concurrent changes;
  - **Support for conflicts resolution** when the same file (the same part of the file) has been simultaneously changed by several developers;
  - Determine the author and time of the changes.

History Overview

- 1972 – Source Code Control System (SCCS) *UNIX*
  - Store changes using deltas
  - Keeps multiple versions of a complete directory
  - Keeps original documents and changes from one version to the next
- 1982 – Revision Control System (RCS) *UNIX*
  - Keeps the current version and applies changes to go back to older versions
  - Single file at a time
- 1986 – Concurrent Versions Systems (CVS)
  - Start as scripts on top of the RCS
  - Handle multiple files at a time
  - Client-Server architecture

Revision Control System (RCS) – Commands

- Create a directory for storing `rcs` files, e.g., `/etc`
- `ci file` – check in a revision (put the file under rcs control)
- `co -l file` – check out a file and lock it [- l] *Locking by means the file can be checked back in*
- `rcs -l file` – lock a file already checked out
- `rcsdiff files` – report on differences between files
- `merge files` – merge two files into an original file

The results has to be checked, it is not a magic!

Revision Control System (RCS) – Example

```
$ mkdir work
$ cd work
$ vim main.sh
$ mkdir RCS
$ ci -u main.sh
RCS/main.sh,v  <--  main.sh
enter description, terminated with single '.' or end of file:
NOTE: This is NOT the log message!
>> My main script
>> .
initial revision: 1.1
done
$ ls RCS
main.sh,v
$ echo "echo 'My script'" >> main.sh

$ rcsdiff main.sh
===================================================================
RCS file: RCS/main.sh,v
retrieving revision 1.1
diff -r1.1 main.sh
1a2
> My script

$ci -u main.sh
RCS/main.sh,v  <--  main.sh
new revision: 1.2; previous revision: 1.1
enter log message, terminated with single '.' or end of file:
>> Add the debug message.
>> .
done
```

Terminology – VCS Vocabulary

- **Repository** – the database storing the files and deltas.
- Working (Local) copy of the versioned files.
  - User works with a copy of the versioned files to modify them.

We can further distinguish local and working copy of the repository (versioned files) for particular VCS. E.g., subversion in addition to working copy also keeps local copy of the files in the `.svn` directory with the version of the files the developer is currently working on. Git keeps a local copy of the repository (usually whole repository) in the `.git` directory.

- **Trunk** – The primary location for the particular project files in the repository.
- **Branch** – A secondary code location (for a variant of the project).
- **Revision** – A version of the a file (or repository).
- **Commit** – Storing a bunch of changes to the repository.
- **Revert** – Roll back a commit from the repository.
- **Merge** – Pulling changes from one branch into another.
- **Conflict** – When a file cannot be merged cleanly (*automagicaly*).

Repository and Version Control

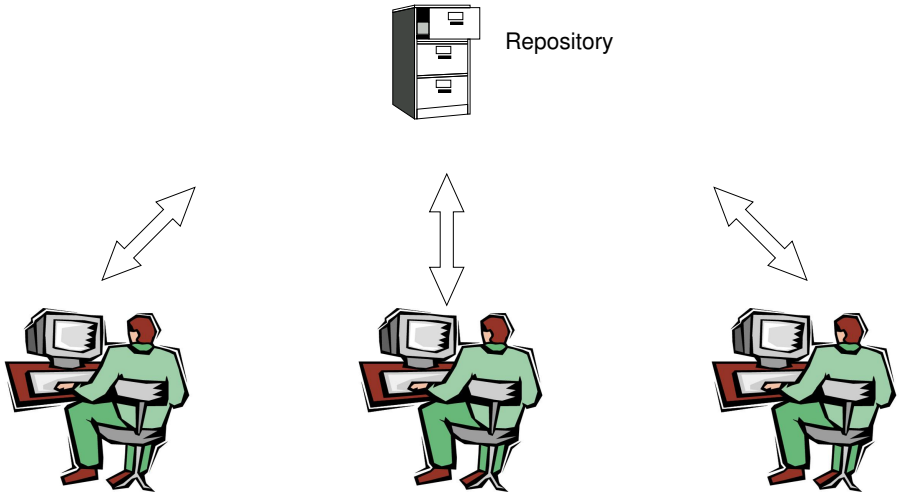
- Version Control System (VCS) is a set of tools (commands) for interaction with the repository and location files (copies of the versioned files).

  A tool is a command or "icon" or an "menu item."

- Local command or in the case of the repository also a server service.
- **Repository**
  - All changes are stored in the repository.

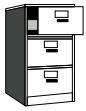
    Usually as deltas, which store differences, and thus save file size.
  - Repository can be remote or local.

Versioning Files



Getting Local/Working Copy – **checkout**

- Create a local copy of the versioned files from the repository.
- Directory tree of the local copy usually contains additional files with the information about the versioned files, revisions, and repository, e.g., `.git` or `.svn`.
- Then, by modifying checkouted files, we modify the local copies of the particular version of the files.



Repository

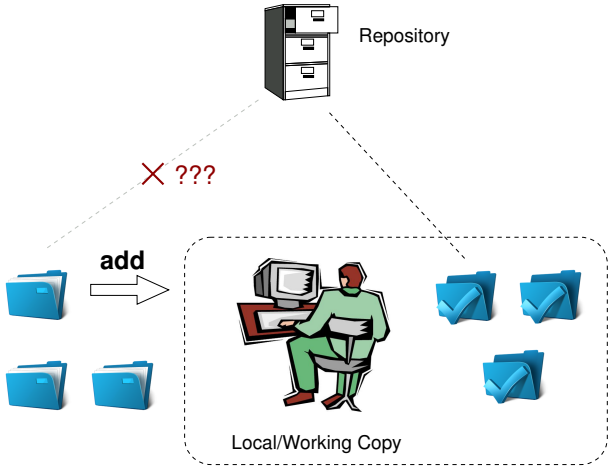
checkout

Local/Working Copy

Adding a File to the Version Control – **add**

- It is necessary to inform the version control system to track particular files under version control, e.g., once (`svn`) or every time a change should be propagated to the repository (`git`).

  Without explicit adding files, the VCS does not know which files we would like to keep under version control and which not.



Confirm Changes to the Repository – **commit**

- Request to accept the local modifications as a new revision of the files.
- Version control system creates the closest higher version, e.g., with the revision number increased by one.
- For the case there is not a newer revision in the repository (according to the local copy of the repository modified locally), changes are propagated to the repository;
- Otherwise:
  - Update the locally copy of the versioned files to the newer version from the repository.
  - If merges are not handled "automagically", it is necessary to handle conflicts.

Notice, each commit should be commented by a meaningful, clear, and not obvious comment.

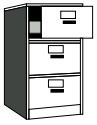
Repository

commit

Local/Working Copy

Update the Local Version of the Files from the Repository - **update**

- **Update** the current local copy of the versioned files to a newer (or specified) revision from the repository.
- If changes of the versioned files is compatible with local modifications, files are *automagically* merged.
- Otherwise it is necessary to manage the conflicts and select the correct version manually.



Repository

update

Local/Working Copy

Resolving Conflicts

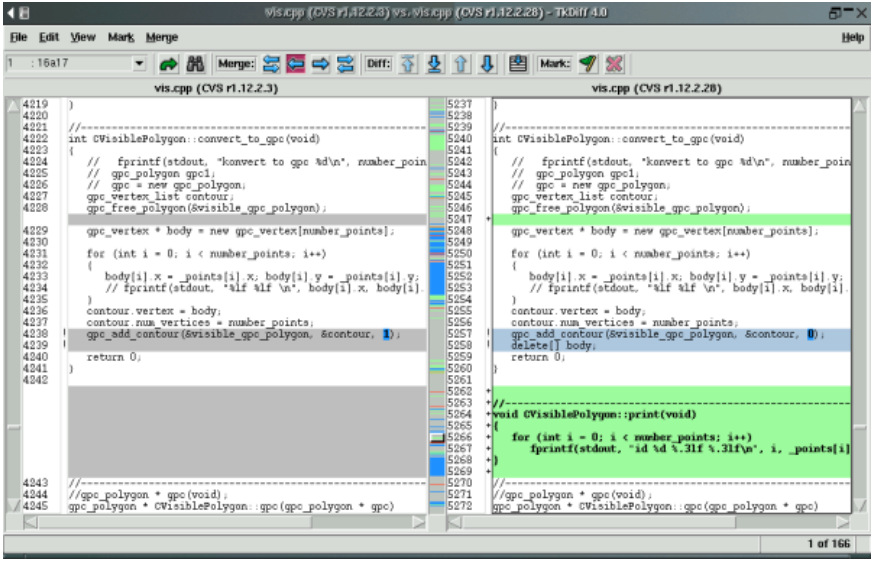
- **Manger of the report** and the VCS does not prevent the conflicts, but it provides **tools for resolving the conflicts**.
- Conflict is usually caused by simultaneous modification of the same part in the source file.
- Conflicts can be avoided by suitable structure of the source files, using modules, and the overall organization of the project files.
- Conflicts can be further avoided by specifying access rights to particular files and developers (authorization).

It might put different demands on the VCS, e.g., Subversion, Bitkeeper vs. Git.

Example of the Merge File with Marked Conflict

```
1169        fprintf(stdout, "%d [%.3lf, %.3lf]\n", i,
1170     }
1171 <<<<<<< vis.cpp
1172     G=12*cities.number;
1173     //G=12.41*4+0.06;
1174 =======
1175     G=12.41*cities.number+0.06;
1176 >>>>>>> 1.12.2.48
1177     separate = false;
1178     return 0;
1179 }
1180
1181 /// ---------------------------------------------
1182 int CMap::coords_size(double * min_x, double * m
1183 {
```

Visualization of Differences



Tagging – Time Marking

- VCS keeps the history of the versioned files.
- We can label the particular state of the repository in the time by a **tag**, e.g., Release_1.0.
- Tag – is a symbolic name for a particular version (state) of the repository.
- **HEAD** tag is usually used for the current version of the repository.

Branching and Branch Names

- Branching allows working in parallel on different ideas/streams/implementations, e.g.,
  - Incremental update to newer techniques and technologies;
  - Testing and evaluation of novel approaches before including them into the main product branch.

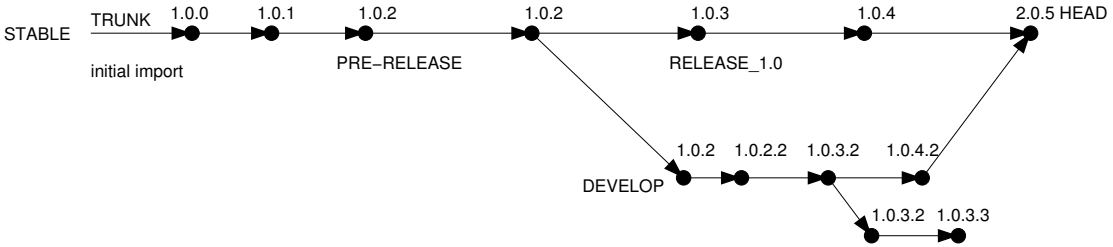
There are common branch names:

- CURRENT, TRUNK - the main development branch
- STABLE - stable development branch

Commit into to the STABLE branch should not disrupt the activities of other developers. E.g., before merging into the STABLE branch, all changes in API should be propagate to other parts.

Using many branches for the development, branch merge may be the crucial property of the version control system, e.g., one of the strong point of `git`.

Example of Branches



Centralized vs. Distributed

Centralized

- Single repository
  - Precisely specified source of record.

    Straightforward authorization.

    Single point of failure (server).
  - Version ids are usually sequential numbers

    Easy to remember and referenced.

    Revision number can be the whole repository.
- For the server hosted repository, network connection might be required.

  For code sharing, it must be available anyway.
- Generally less use of branching for experimentation.

Distributed

- Every user has a full copy of the repository.

  Complicated authorization.

  Redundant copies, more robust to failures

  May require unnecessary data space for huge repositories, e.g., for a single
- Offline work usually possible.

  Commit to local repository.
- Version IDs are usually GUIDs (Globally Unique IDentifiers).
- More branching and sharing.

Example of VCS

- Also called Source Code Manager (SCM).
- Many VCSs exist as both free/open source and proprietary.

https://en.wikipedia.org/wiki/List_of_version_control_software

- Local only: SCCS (1972), RCS (1982), PVCS[1] (1985), QVCS[1] (1991).
- Client-server: CVS (1986), ClearCase[1] (1992), Perforce[1] (1995), Subversion (2000), Surround SCM[1] (2002), Visual Studio Team Services[1] (2014).
- Distributed: BitKeeper (1998), Darcs (2002), SVK (2003), Bazaar (2005), Mercurial (2005), Git (2005), Plastic SCM[1] (2006), Visual Studio Team Services (2014)[1]
- Free/open-source – **Subversion**, **Git**
- Proprietary – Surround SCM, Plastic SCM

http://www.seapine.com/surround-scm/overview, https://www.plasticscm.com

[1] Proprietary

It is good to known and be aware that various systems are available and what are their limitations and features. Knowledge of fundamental principles may help you to make a right choice.

https://en.wikipedia.org/wiki/Comparison_of_version_control_software

Git and Subversion – Main Difference

- **Git** – Distributed repository approach (primarily)
  - Every checkout of the repository can be a full repository with complete history. *Might be turn to a server based, but with redundant commands.*
  - High redundancy with efficient data transfer.
  - Designed for branching and merging repositories.

    Branches and tags are "markers" of the subset of the repository.
- **Subversion** – Central repository approach (primarily)
  - The main repository is the only source that has the complete file history.
  - Users checkout local copies of the current version.
  - Strong support of authorization to particular directories.
  - The revision id is a number for the whole repository.
  - Tags and branches are directories (based on the concept of cheap-copy)

    Allows easy and straightforward multiple versions (branches/tags) alongside, which is very difficult in Git.

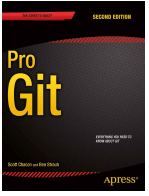
What the best fits your needs depends on the way how you expect to use it. It also holds for single user usage. Imagine a situation with a single main laptop (btw. try to never rely on a single HDD/SSD). Or a situation with several workstations and laptops.

Learn what you need!

Literature

- For both systems Git and Subversion, there are several books also available for download or on-line readings.
- **Git**

  https://git-scm.com/book/en/v2



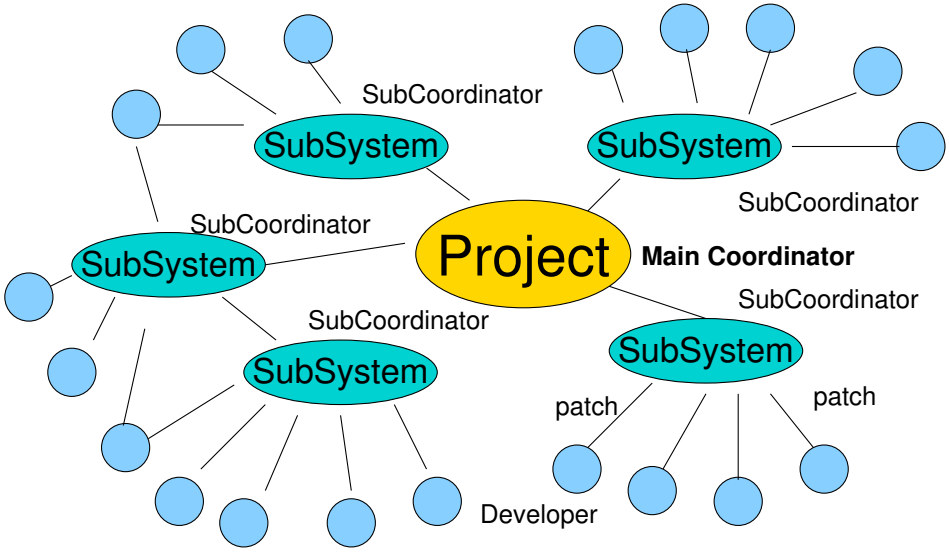
- **Subversion**

  http://svnbook.red-bean.com/
  https://subversion.apache.org/docs/

Distributed Version Control System (DVCS)

- DVCS does not necessarily have a central repository.
- Each developer keeps its own *local* repository.
- Branches are usually used very often (locally without interaction to other developers).
- The final project is a compilation of particular branches by individual developers.
- Beside Git, there are several another systems:
  - Bazaar – **bzr**; Monotone - `http://www.monotone.ca`; SVK – based on Subversion
  - Darcs (**darcs**) – David's Advanced Revision Control System; `http://darcs.net`
    Written in Haskell
  - Mercurial – `http://www.selenic.com/mercurial/wiki`
  - BitKeeper - `http://www.bitkeeper.com`.
  - Perforce, Plastic SCM – *proprietary software*
  - Git – **git** – created for developing the Linux kernel `http://git-scm.com`

Git – Development of the Linux Kernel Model with Many Developers



Git – Properties and Features

- Local repository allows versioning without network connection.
  The central repository is substituted by a responsible developer.
- Commit only adds the changes to the local repository therefore it is necessary to propagate the changes to the upstream using git push.
- Can be efficient for large projects. *But it may also not be suitable.*
- Files are stored as objects in a database (INDEX). *SHA1 fingerprints as file identifiers.*
- Low-level operations on top of the database are encapsulated by more user-friendly interface. *The very first interface was very difficult to use.*
- Support development with a high usage of **branches**.
- Support for applying patch sets, e.g., delivered by e-mails.
- **Tags** and **Branches** are marked points/states of the repository.
- Suitability of the Git deployment depends on the project and model of the development.

Git – Usage

- `git clone` *path to git repository* – create a copy of the repository (in `.git` directory).
- `git remote` – setup of the repository following (`git fetch`).
- `git help` *command* – get help info about a particular command.
- `git add`, `git status`, `git log`, `git merge`, `git rm` – commands for local versioning.
- `git checkout` *files* – update the files from the repository (or branch).
- `git branch` *branch name* – initial a new branch based on the current revision.

- `git pull` – update local repository with new revision at the remote repository.
- `git push` – propagate local repository to a remote repository.

Git – Example

```
% mkdir my_project
% cd my_project
% git init
Initialized empty Git repository in ~/my_project/.git/
% git init
% vim main.c
% git add main.c
% git st
On branch master

Initial commit

Changes to be committed:
  (use "git rm --cached <file>..." to unstage)

    new file:   main.c

% git ci -m "Add main program"
[master (root-commit) ab2afdf] Add main program
 1 file changed, 7 insertions(+)
    create mode 100644 main.c
% git st
On branch master
nothing to commit, working tree clean
% git log
commit ab2afdfc60e7702f1452288c83f97e6a6926e53c
Author: Jan Faigl <faiglj@fel.cvut.cz>
Date:   Sun Dec 18 17:35:23 2016 +0100

    Add main program
```

FEL, GitLab

`https://gitlab.fel.cvut.cz`

- You can use faculty gitlab server for versioning sources of your semestral projects and assignments.
- After the cloning the repository to your local repository.

  You can `push` your changes in the local repository and `pull` modifications from the repository, e.g., made by other developers.
- You can also control access to your repositories and share them with other FEL users.

  Collaboration with other students on the project

- You need to create your private/public ssh-key to access to the GitLab.
- Using server based git repository, you can combine advantages of local versioning with server based backup.

Subversion – http://subversion.apache.org

- Apache Subversion 1.14.1 Release (2021-02-10)

  LTS release with 4 years support period (release every 2 years - ver. 1.10, 1.14, etc.)

  - Milestone 1 - September 2000,
  - Subversion 0.8 - January 2002,
  - Subversion 0.37 (1.0.0-RC1) - January 2004,
  - Subversion 1.0.0 - February 2004,
  - Subversion 1.1.0 - September 2004,
  - Subversion 1.2.0 - May 2005,
  - Subversion 1.3.0 - January 2006,
  - Subversion 1.4.0 - September 2006,
  - Subversion 1.5.0 - June 2008,
  - Subversion 1.6.0 - March 2009
  - Subversion 1.7.0 - October 2011 (Apache Foundation),
  - Subversion 1.8.0 - June 2012,
  - Subversion 1.9.0 - August, 2015
  - Subversion 1.11.0 - October, 2018
  - Subversion 1.12.0 - April, 2019
  - Subversion 1.13.0 - October, 2019
  - Subversion 1.14.0 - May, 2020

https://subversion.apache.org/docs/release-notes/release-history.html

SVN – Setting up a repo

- `svnadmin` – administration changes to the SVN repository.
- `svn` – for interaction with an SVN repository.

  Can be used from other applications / scripts / GUIs or using particular library calls.
- The repository can be setup
  - Locally using local path to the repository .

```
svnadmin create /repos/myrepos
svn checkout file:///repos/myrepos my_project
```

    or using ssh account

```
svn checkout svn+ssh://mypc.cvut.cz/repos/myrepos my_project
```

- As a server service using
  - `ssh`
  - `svnserver`
  - `http` and `https` – apache2 `mod_dav_svn_module`.

Authentication via http(s) seesions, e.g., using LDAP

Authorization using svn-auth-file

SVN – Commands 1/2

- `svn add` *files* – schedule files to be added at the next commit.
- `svn ci` *[files]* - commit / check in changed files.
- `svn co` *[files]* – check out
- `svn update` *[files]* - update local copy to the latest version.

  (or specified version using `-r`)
- `svn help` *[command]* – get help info about a particular command.
- `svn status` *[files]* – get info about the files.
- `svn info` – get info about the local repository and local copy.
- `svn diff` *[files]* – list of changes of the local working files to the local copy.
- `svn log` *[files]* – list commit changes.

SVN – Commands 2/2

- `svn revert` *files* – restore working copy to the repo's version.
- `svn merge` *source path* – merge changes.
- `svn resolve` *source path* – resolve merging conflicts.
- `svn resolved` *files* – mark the files as conflicts resolved.

E.g., after manual editing or using other tools.

- Further commands are, e.g., `blame`, `changelist`, `mkdir`, `ls`, `mv`, `lock`/`unlock`, `propset`, etc.
- A file can be removed from the versioning by `svn rm` *files*.
  - The previous versions of the file are kept in the repository as a part of the history.
  - The real deletion of the file is not possible (straightforwardly) – it contradicts the main versioning philosophy.

Obliterate feature is planned for Subversion ver. 2.0?
`https://subversion.apache.org/roadmap.html`

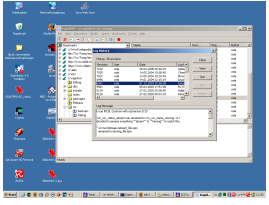
Subversion – Example

```
mkdir ~/svn
% svnadmin create ~/svn/my_project
% svn co file:///$HOME/svn/my_project
Checked out revision 0.
% cd my_project
% vim main.c
% svn add main.c
A         main.c

% svn ci -m "Add main program"
Adding         main.c
Transmitting file data .done
Committing transaction...
Committed revision 1.

% svn info
Path: .
Working Copy Root Path: /home/jf/my_project
URL: file:///home/jf/svn/my_project
Relative URL: ^/
Repository Root: file:///home/jf/svn/my_project
Repository UUID: 72237e9d-24c5-e611-beef-9c5c8e834429
Revision: 0
Node Kind: directory
Schedule: normal
Last Changed Rev: 0
Last Changed Date: 2016-12-18 14:19:33 +0100 (Sun, 18 Dec 2016)

% svn up
Updating '.':
At revision 1.
```

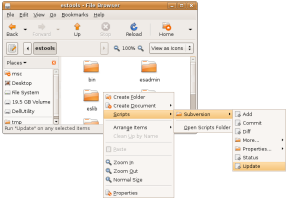
Subversion – Shell and IDE Integration – Examples

https://en.wikipedia.org/wiki/Comparison_of_Subversion_clients

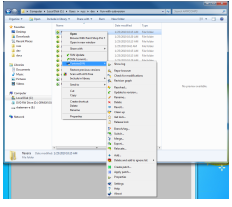
RapidSVN



Nautilus Integration

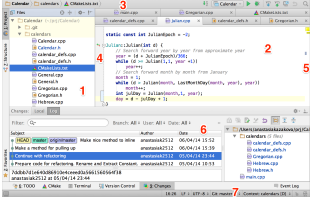


TortoiseSVN



https://tortoisesvn.net/ExplorerIntegration.html

CLion



https://www.jetbrains.com/help/clion/2021.1/clion-quick-start-guide.html#customize-the-environment

Git – SVN Crash Course

`git init`	`svnadmin create repo`
`git clone url`	`svn checkout url`
`git add file`	`svn add file`
`git commit -a`	`svn commit`
`git pull`	`svn update`
`git status`	`svn status`
`git log`	`svn log`
`git rm file`	`svn rm file`
`git mv file new_file_name`	`svn mv file new_file_name`
`git checkout rev`	`svn update -r rev`
`git tag -a name`	`svn copy repo/trunk repo/tags/name`
`git branch branch`	`svn copy repo/trunk repo/branches/branch`
`git checkout branch`	`svn switch repo/branches/branch`

http://git.or.cz/course/svn.html

Wrap-Up – What You Can Put under Version Control?

- Source codes of your programs.
- Versioning of the Third-party libraries.

  Even though it make more sense to version source files, i.e., text files, you can also versioning binary files, but you cannot expect a straightforward diff.
- Versioning documents (text/binary)
  - File and Directory Layout for Storing a Scientific Paper in Subversion

    http://blog.plesslweb.ch/post/6628076310/file-and-directory-layout-for-storing-a-scientific
- You should definitely put sources of your diploma or bachelor thesis under version control

  Also as a sort of backup.

  Even you will use it only for your thesis, TEX or LATEX should be your option.
- Repository and version control as an additional "backuping."

  Repository on the server may usually be located on backuped and reliable disk system.
- Versioning can be used as a tool for sharing files.

  Be aware that files are persistent in the repository!

Summary of the Lecture

Topics Discussed

- An overview of history of VCSs
- Fundamental concepts and terminology
- Brief overview of existing VCSs
- Centralized and Distributed VCSs
  - Git – commands and basic usage
  - Subversion – commands and basic usage
- FEL GitLab