

EECS 22L: Software Engineering Project in C Language

Lecture 3

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Lecture 3: Overview

- Software Development Tools, Overview
 - Linux commands and tools
 - Scripting languages, shells
 - IDEs, source code management tools
- Source Code Management
 - Collaborative software development
 - Version trees
 - Concurrent Versions System (CVS)
 - Detailed development example

Software Development Tools, Overview

- Linux Commands and Tools
 - Basic system commands [see EECS22 Lecture 1]
 - `echo` print a message
 - `date` print the current date and time
 - `ls` list the contents of the current directory
 - `cat` list the contents of files
 - `more` list the contents of files page by page
 - `pwd` print the path to the current working directory
 - `mkdir` create a new directory
 - `cd` change the current directory
 - `cp` copy a file
 - `mv` rename and/or move a file
 - `rm` remove (delete) a file
 - `rmdir` remove (delete) a directory
 - `man` view manual pages for system commands and tools

Software Development Tools, Overview

- Linux Commands and Tools
 - Text editors [see EECS22 Lecture 1]
 - `vi` standard Unix editor
 - `vim` vi-improved (supports syntax highlighting, and much more...)
 - Can compare two files (like `diff`) and visualize the differences
 - `vim -d fibonacci.c fibonacci2.c`
 - `pico` easy-to-use text editor
 - `emacs` very powerful editor
 - `gedit` nice GUI editor in separate X-window
 - Manual page creation
 - `groff` simple text formatter
 - `groff -man -Tascii man/man1/name.1 >man/cat1/name.1`
 - Online how-to page:
 - <http://www.linuxhowtos.org/System/creatingman.htm>

Software Development Tools, Overview

- Linux Commands and Tools
 - Advanced file system commands
 - **gtar** GNU tape archiver, manage a “tar-ball” package
 - `gtar cvzf package.tar.gz files...` (create an archive)
 - `gtar tvzf package.tar.gz` (view an archive's contents)
 - `gtar xvzf package.tar.gz` (extract an archive)
 - **ln** create (symbolic or hard) links to files
 - `ln -s path_to_file link_name`
 - **chmod** set file access permissions
 - `ls -l filename`
 - `chmod u+rx,g+rx-w,o-rwx filename`
 - `chmod 750 filename`
 - **groups** list group memberships of a user
 - **chgrp** change group for a file
 - `chgrp team7 filename`

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Software Development Tools, Overview

- Scripting Languages
 - Build scripts
 - **make**, **Makefile** [see EECS22 Lecture 11]
 - Cross-platform Make
 - **cmake**

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Software Development Tools, Overview

- General Purpose Shell and Scripting Languages
 - Unix shell, and GNU bourne-again shell
 - `sh`
 - `bash`
 - Berkeley Unix C shell, and extension
 - `csch`
 - `tcsh`
- Remote Shells
 - Secure shell
 - `ssh user@hostname.domain`
 - `scp user@hostname.domain:sourcefile targetfile`
 - Insecure (!) remote shells
 - `rsh`
 - `telnet`

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Software Development Tools, Overview

- Integrated Development Environment
 - `eclipse`
- Software Documentation Generator
 - `doxygen`
- Source Code Management
 - Concurrent Versions System [see details in following slides!]
 - `cvs checkout ...`
 - Subversion
 - `svn checkout ...`
 - Git (the current Linux kernel source code management tool)
 - `git clone ...`

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Source Code Management

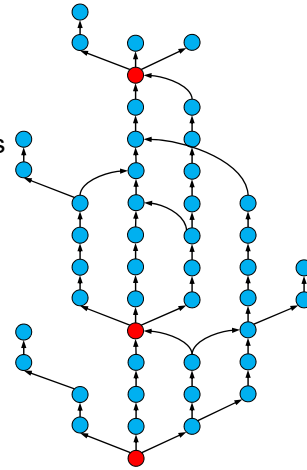
- Source Code Management
 - Also known as *Version Control*
 - or *Configuration Management*
- Purpose and Goals
 - Team-based, *concurrent* software development
 - Access control
 - Archive for software development and versions
 - Efficient storage space usage with remote access
 - Common data base with records of
 - Source code, documentation, and other build files
 - Versions and revisions
 - Branches and merges
 - History and log information

Source Code Management

- Collaborative Software Development
 - *Shared but dependent source code files!*
 - Two options:
 - Single modifications with file *locking*
 - Ensures that no two developers modify the same file at same time
 - But has drawbacks:
 - » Locking may be forgotten
 - » Locking may lead to deadlocks (!)
 - » Locally modified files may lead to mismatches with locked ones...
 - Multiple modifications with *merging*
 - Multiple developers work on the same files at the same time
 - » Multiple modifications are allowed, different versions exist!
 - Files are *merged* when inserted into the common code base (“merge and commit to the repository”)
 - Merging can often be performed automatically!

Source Code Management

- Version Trees
 - Software products consist of versions
 - Release *versions* (*externally visible*)
 - Development *revisions* (internal only)
 - Concurrent feature development requires multiple parallel branches
 - Separate common vs. feature files
 - Only a few of the files actually differ
 - Version trees consist of
 - Major release versions (e.g. 1.0, 2.0, 3.0)
 - Minor development revisions (e.g. 1.1, 1.2, ...)
 - *Root* (e.g. revision 0.0) and main *trunk*
 - *Branches* for features (1.0.1, 1.0.2, ...)
 - May be active (open) or dead (closed)
 - May be merged into other branches



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Source Code Management

- Version Control with *Concurrent Versions System (CVS)*
 - Overview
 - Creating a CVS repository
 - Starting a project
 - Checking out a project
 - Checking in updated files
 - Adding new files
 - Concurrent updating and merging
 - Advanced features

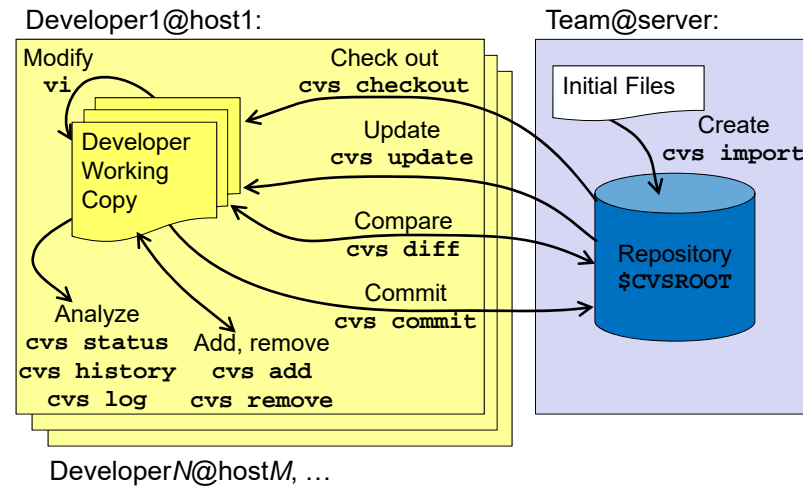
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Version Control with CVS

- Overview: Concurrent Versions System (CVS)



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Version Control with CVS

- Step 1: Creating a CVS repository
 - Repository can host multiple projects (aka. CVS modules)
 - One repository per team
 - Repository should be located at central position
 - On server, team-accessible
 - Example: Team **eeecs22** *initializes* its CVS repository
 - Repository location: `~eeecs22/cvsroot` on server **ladera**



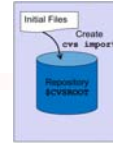
```
doemer@ladera:1 > ssh eeecs22@ladera
eeecs22@ladera's password:
Last login: Mon Jan 14 21:28:15 2013 from ladera.eecs.uci.edu
eeecs22@ladera:1 > ls cvsroot
ls: cvsroot: No such file or directory
eeecs22@ladera:2 > cvs -d ~/cvsroot init
eeecs22@ladera:3 > ls cvsroot
CVSROOT/
eeecs22@ladera:4 > exit
logout
Connection to ladera closed.
doemer@ladera:2 >
```

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Version Control with CVS



- Step 2: Starting a project in the repository
 - Example: Team prepares initial file tree and *imports* the project
 - Environment variable `CVSROOT` points to the repository location
 - The `Makefile` and the `src` and `bin` directories are imported

```
eecs22@ladera:1 > mkdir project
eecs22@ladera:2 > mkdir project/chess
eecs22@ladera:3 > cd project/chess
eecs22@ladera:4 > mkdir init
eecs22@ladera:5 > cd init
eecs22@ladera:6 > vi Makefile
eecs22@ladera:7 > mkdir src bin
eecs22@ladera:8 > setenv CVSROOT ~/cvsroot
eecs22@ladera:9 > cvs import -m "Created initial file tree"
                        project/chess doemer start

N project/chess/Makefile
cvs import: Importing /users/eecs22/cvsroot/project/chess/src
cvs import: Importing /users/eecs22/cvsroot/project/chess/bin

No conflicts created by this import

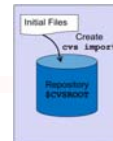
eecs22@ladera:10 >
```

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Version Control with CVS



- Step 2: Starting a project in the repository
 - Example (cont'd): Team inspects the repository
 - Repository now contains `project/chess/` sub-directory
 - Each imported file/directory has a corresponding repository entry
 - Each repository file contains all revisions of the corresponding file
 - Only revision *differences* are appended (file contents are “diffs”)

```
eecs22@ladera:10 > ls -la ~/cvsroot/
total 4
drwxrwxr-x  4 eeecs22 mysql  512 Jan 14 22:06 ./
drwxr-xr-x 34 eeecs22 mysql 1024 Jan 14 22:04 ../
drwxrwxr-x  3 eeecs22 mysql 1024 Jan 14 22:04 CVSROOT/
drwxrwxr-x  3 eeecs22 mysql  512 Jan 14 22:06 project/
eecs22@ladera:11 > ls -la ~/cvsroot/project/chess/
total 6
drwxrwxr-x  5 eeecs22 mysql  512 Jan 14 22:06 ./
drwxrwxr-x  3 eeecs22 mysql  512 Jan 14 22:06 ../
drwxrwxr-x  2 eeecs22 mysql  512 Jan 14 22:06 bin/
-r--r--r--  1 eeecs22 mysql  405 Jan 14 22:06 Makefile,v
drwxrwxr-x  2 eeecs22 mysql  512 Jan 14 22:06 src/
eecs22@ladera:12 >
```

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Version Control with CVS

• Step 3: *Checking out* a project copy

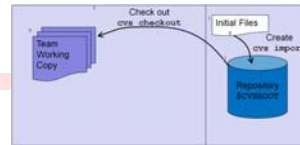
- Example: Team creates a central project check-out
 - Directory `chkout` is created next to the initial `init` directory
 - After the `chkout` contents are confirmed OK and complete, the initial `init` directory tree should be deleted (not used anymore)

```
eecs22@ladera:12 > cd ~/project/chess
eecs22@ladera:13 > cvs checkout -d chkout project/chess
cvs checkout: Updating chkout
U chkout/Makefile
cvs checkout: Updating chkout/bin
cvs checkout: Updating chkout/src
eecs22@ladera:14 > ls
chkout/ init/
eecs22@ladera:15 > cd chkout/
eecs22@ladera:16 > ls
bin/ CVS/ Makefile src/
eecs22@ladera:17 > cd ..
eecs22@ladera:18 > rm -rf init
eecs22@ladera:19 > ls
chkout/
eecs22@ladera:20 >
```

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Version Control with CVS

• Step 4: *Checking out* a *working copy*

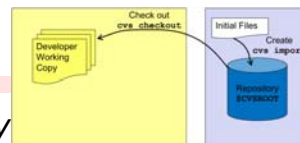
- Example: Developer prepares a local project checkout
 - Directory `project/chess` is created to host local checkouts
- Preparation: Set CVS environment variables
 - `CVSROOT` access method, login, and server name, plus absolute path to the repository
 - `CVS_RSH` protocol to use to connect to the server
 - `CVSUMASK` mask for file permissions suitable for teamwork

```
doemer@ladera:1 > mkdir project
doemer@ladera:2 > mkdir project/chess
doemer@ladera:3 > cd project/chess
doemer@ladera:4 > echo ~eecs22
/users/eecs22
doemer@ladera:5 > setenv CVSROOT
:ext:eecs22@ladera.eecs.uci.edu:/users/eecs22/cvsroot
doemer@ladera:6 > setenv CVS_RSH ssh
doemer@ladera:7 > setenv CVSUMASK 007
doemer@ladera:8 >
```

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Version Control with CVS

- Step 4: Checking out a *working copy*
 - Example (cont'd): Developer checks out a local project copy
 - Project `project/chess` is checked out
 - Checkout is placed into new directory named `chkout`
 - Created files are *updated* to latest versions (on main trunk)
 - Developer can then start working in `chkout` directory...

```
doemer@ladera:8 > cvs checkout -d chkout project/chess
eecs22@ladera.eecs.uci.edu's password:
cvs checkout: Updating chkout
U chkout/Makefile
cvs checkout: Updating chkout/bin
cvs checkout: Updating chkout/src
doemer@ladera:9 > ls
chkout/
doemer@ladera:10 > cd chkout
doemer@ladera:11 > ls
bin/ CVS/ Makefile src/
doemer@ladera:12 >
```

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Version Control with CVS

- Step 5: Checking in updated files
 - Example (cont'd): Developer works in local project checkout
 - Developer modifies/extends the `Makefile`
 - Developer *commits* the updated `Makefile` to the repository
 - A message describing the change should be attached
 - New revision 1.2 of `Makefile` is checked into the repository
 - New `Makefile` becomes available to other team members

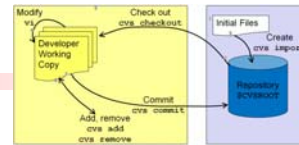
```
doemer@ladera:12 > vi Makefile
doemer@ladera:13 > cvs commit -m "Added default rules"
cvs commit: Examining .
cvs commit: Examining bin
cvs commit: Examining src
eecs22@ladera.eecs.uci.edu's password:
Checking in Makefile;
/users/eecs22/cvsroot/project/chess/Makefile,v <-- Makefile
new revision: 1.2; previous revision: 1.1
done
doemer@ladera:14 >
```

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Version Control with CVS



- Step 6: Adding new files

- Example (cont'd): Developer works in local project checkout
 - Developer creates a new source file `Main.c` (in directory `src`)
 - Developer *adds* and *commits* the new file to the repository
 - (Deleting unused files works the same way with `remove`)

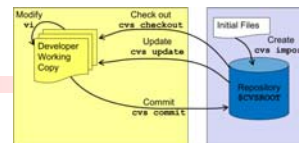
```
doemer@ladera:14 > vi src/Main.c
doemer@ladera:15 > cvs add src/Main.c
eecs22@ladera.eecs.uci.edu's password:
cvs add: scheduling file `src/Main.c' for addition
cvs add: use 'cvs commit' to add this file permanently
doemer@ladera:16 > cvs commit -m "Added Main.c with menu" src
cvs commit: Examining src
eecs22@ladera.eecs.uci.edu's password:
RCS file: /users/eecs22/cvsroot/project/chess/src/Main.c,v
done
Checking in src/Main.c;
/users/eecs22/cvsroot/project/chess/src/Main.c,v <-- Main.c
initial revision: 1.1
Done
doemer@ladera:17 >
```

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Version Control with CVS



- Step 7: Concurrent update, merging

- Example: Developer 1 works in local project checkout
 - Developer 1 checks for any updates in the repository
 - If no updates are available, status of local files is shown

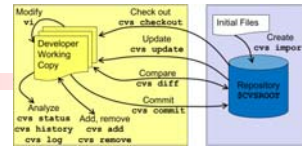
```
doemer@ladera:1 > cd project/chess/chkout/
doemer@ladera:2 > ls
bin/ CVS/ Makefile src/
doemer@ladera:3 > cvs update
eecs22@ladera.eecs.uci.edu's password:
cvs update: Updating .
cvs update: Updating bin
cvs update: Updating src
doemer@ladera:4 > vi Makefile
doemer@ladera:5 > cvs update
eecs22@ladera.eecs.uci.edu's password:
cvs update: Updating .
M Makefile
cvs update: Updating bin
cvs update: Updating src
doemer@ladera:6 >
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 1 works in local project checkout
 - Developer 1 can compare (*diff*) her/his local files anytime against the latest revision in the repository
 - Comparison against any other revision is also possible (using the `-r` revision option)

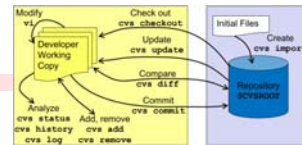
```
doemer@ladera:6 > cvs diff Makefile
eecs22@ladera.eecs.uci.edu's password:
Index: Makefile
=====
RCS file: /users/eecs22/cvsroot/project/chess/Makefile,v
retrieving revision 1.2
diff -r1.2 Makefile
2a3,6
>
> # module 1 compilation rule
> module1.o: module1.h module1.c
>     gcc module1.c -o module.o
doemer@ladera:7 >
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 2 works *in parallel* in team account
 - Developer 2 modifies/extends the **Makefile**
 - Developer 2 explicitly checks the *status* of the **Makefile** and finds that a newer version is available in the repository

```
eecs22@ladera:1 > cd project/chess/chkout/
eecs22@ladera:2 > ls
bin/ CVS/ Makefile src/
eecs22@ladera:3 > vi Makefile
eecs22@ladera:4 > cvs status Makefile
=====
File: Makefile           Status: Needs Merge

Working revision:      1.1.1.1 Tue Jan 15 06:06:31 2013
Repository revision:  1.2
/users/eecs22/cvsroot/project/chess/Makefile,v
Sticky Tag:            (none)
Sticky Date:           (none)
Sticky Options:        (none)

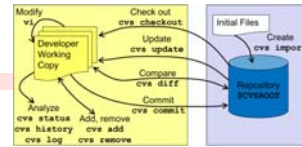
eecs22@ladera:5 >
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 2 works *in parallel* in team account
 - Developer 2 modifies/extends the **Makefile**
 - Developer 2 explicitly checks the status of the **Makefile**
 - Developer 2 *updates* his local checkout, i.e. the **Makefile**
 - Two sets of changes in **Makefile** are *merged* (here with conflicts)

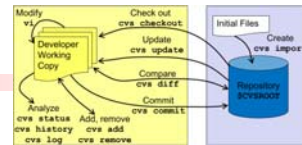
```
eecs22@ladera:5 > cvs update
cvs update: Updating .
RCS file: /users/eecs22/cvsroot/project/chess/Makefile,v
retrieving revision 1.1.1.1
retrieving revision 1.2
Merging differences between 1.1.1.1 and 1.2 into Makefile
rcsmerge: warning: conflicts during merge
cvs update: conflicts found in Makefile
C Makefile
cvs update: Updating bin
cvs update: Updating src
U src/Main.c
eecs22@ladera:6 >
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 2 works *in parallel* in team account
 - Developer 2 modifies/extends the **Makefile**
 - Developer 2 explicitly checks the status of the **Makefile**
 - Developer 2 updates his local checkout, i.e. the **Makefile**
 - Two sets of changes in **Makefile** are merged (here with conflicts)
 - Developer 2 resolves the conflicts (an example is shown later) and *commits* the merged revision back into the repository

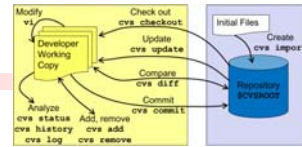
```
eecs22@ladera:6 > vi Makefile
eecs22@ladera:7 > cvs commit -m "Added rule and resolved conflicts"
cvs commit: Examining .
cvs commit: Examining bin
cvs commit: Examining src
Checking in Makefile;
/users/eecs22/cvsroot/project/chess/Makefile,v <-- Makefile
new revision: 1.3; previous revision: 1.2
done
eecs22@ladera:8 >
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 1 works in local project checkout
 - Then, after parallel edits in her/his local files, Developer 1 tries to commit her/his changes to the repository
 - CVS examines the local version against the latest revision in the repository, and finds a newer version
 - Developer 1 needs to update and merge her/his version first before she/he can commit the changes!

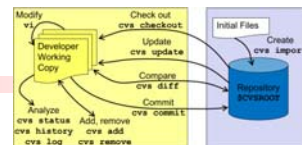
```
doemer@ladera:7 > cvs commit -m "Added my module"
cvs commit: Examining .
cvs commit: Examining bin
cvs commit: Examining src
eecs22@ladera.eecs.uci.edu's password:
cvs commit: Up-to-date check failed for `Makefile'
cvs [commit aborted]: correct above errors first!
cvs commit: saving log message in /tmp/cvsgPQeeD
doemer@ladera:8 >
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 1 works in local project checkout
 - Developer 1 *updates* her/his local **Makefile**
 - CVS merges the missing changes from the repository into the local **Makefile**
 - Conflicts are found and marked in the updated local **Makefile**
 - Developer 1 needs to resolve these conflicts manually!

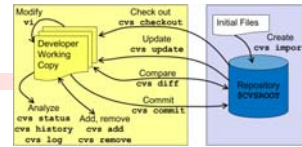
```
doemer@ladera:8 > cvs update Makefile
eecs22@ladera.eecs.uci.edu's password:
RCS file: /users/eecs22/cvsrcroot/project/chess/Makefile,v
retrieving revision 1.2
retrieving revision 1.3
Merging differences between 1.2 and 1.3 into Makefile
rcsmerge: warning: conflicts during merge
cvs update: conflicts found in Makefile
C Makefile
doemer@ladera:9 > vi Makefile
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 1 works in local project checkout
 - Developer 1 opens the **Makefile** to resolve the conflicts
 - Conflicting lines are listed between <<<< and >>>> markers
 - In this example, both changes are valid, only the three marking lines need to be removed!

```
# Makefile:
# 01/17/13 by R. Doemer

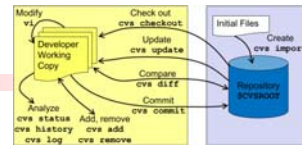
<<<<<< Makefile
# module 1 compilation rule
module1.o: module1.h module1.c
    gcc module1.c -o module.o
=====
module2.o: module2.c module2.h
    gcc module2.c -o module.o
>>>>>> 1.3
~
~
"Makefile" 11L, 202C                                6,1      All
```

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Version Control with CVS



- Step 7: Concurrent update, merging
 - Example (cont'd): Developer 1 works in local project checkout
 - Developer 1 saves the **Makefile** with the resolved conflicts
 - Developer 1 then commits the properly merged version to the repository
 - Note: If no message is supplied with the **commit** command, the default editor is opened for a log message to be typed in.

```
doemer@ladera:10 > cvs commit -m "Added my module and fixed merge"
cvs commit: Examining .
cvs commit: Examining bin
cvs commit: Examining src
eecs22@ladera.eecs.uci.edu's password:
Checking in Makefile;
/users/eecs22/cvsroot/project/chess/Makefile,v <-- Makefile
new revision: 1.4; previous revision: 1.3
done
doemer@ladera:11 >
```

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Version Control with CVS

- Advanced CVS features:
 - Tagging:
 - Revision numbers are automatically assigned by CVS in increasing order and are generally different for different files
 - Specific revisions can be tagged with descriptive name tags
 - Example: `cvs tag ReleaseAlpha`
 - Tags can then be used instead of revision numbers
 - Advise: Properly tag all releases for easy retrieval later!
 - Branching:
 - Development branches are created in the repository
 - Example: `cvs tag -b branch_name`
 - Development branches can be checked out by name
 - Example: `cvs checkout -r branch_name`
 - Development branches can be merged into another branch
 - Example: `cvs update -j branch_name`

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Version Control with CVS

- Advanced CVS features (cont'd):
 - Binary files:
 - Since revisions are internally stored in diff format, files are generally assumed to be regular text files
 - Binary files (e.g. PDF, JPG, MP3, etc.) must be added to a CVS repository with `-kb` option
 - Example: `cvs add -kb filename`
 - For more detailed information, read the CVS Manual!
 - “*Version Management with CVS*” by Per Cederqvist et al.
 - Online available at <https://eee.uci.edu/18w/18020/resources.html>

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