CS110 Discussion

Week2

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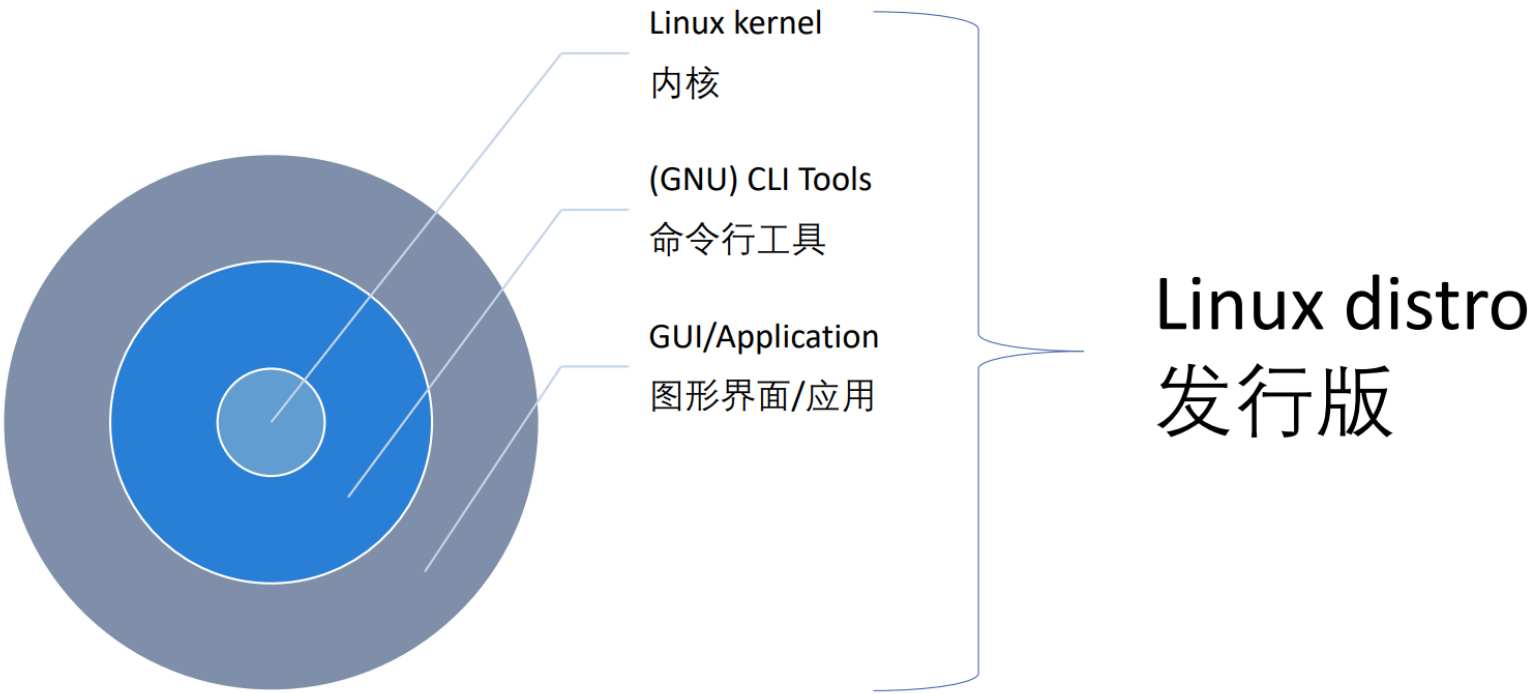
content

preface

- Not just a discussion, more like an **Lab**.
- Lots of **practical content**, a little hard for Linux beginners.
- There will be **code and command line operations**.

What is Linux

- Linux is a family of open-source Unix-like **operating systems** based on the Linux kernel.
- There are lots of Linux distributions such as Ubuntu, Debian, Arch, NixOS...



Install a Linux system

- Opt1: dual system
- Opt2: virtual machine(a in-class demo)
  - Easy to start kubuntu20.04, 22.04 virtual machine: Linux 101
  - ubuntu20.04, 22.04, 24.04 image: Tsinghua mirrors
  - VMware workstation player
- WSL is not suggested

Shell and terminal

- **Shell**: A family of programs which enable user to interact with kernel, like bash, csh, zsh...
- **Terminal**: A TUI/GUI where user can type in their command. Each time a terminal is created, it will run shell.
  - **Gnome Terminal**: enter `ctrl+alt+T` to open gnome default GUI terminal
  - **TTY**: enter `ctrl+alt+F1` to open TUI terminal

Basic usage of Shell

Some frequently used command

- **ls** : list all the files and directories under current directory
- **mkdir [*name*]** : create an empty under current directory
- **rm [*file..*]** : delete files
- **sudo** : do some thing with superuser privileges
- **apt install** : install commands using apt
- **man [*command*]** : show manual of the command
  - **tldr [*command*]** : show the simplified manual of a command

Shell script

- Shell script is a file written by commands and shell syntax.
- The shell will interrupt and execute it
- A simple demo here

```
1   #!/bin/sh
2
3   echo "hello,world"
4   ls
5   mkdir hello
6   cd hello
7   touch hello.c
```

Reference about shell syntax and script

- Missing Semester of Your CS Education: MIT's beginner-oriented Linux courses, **highly recommanded!**
- Linux 101 chapter9: Introduction to useful command line tools.
- Bash scripting cheatsheet: A table of common Bash syntax

Introduction of Git

Git is a **distributed version control** system that tracks changes in any set of computer files, usually **used for coordinating work** among programmers collaboratively developing source code during software development.

In the beginning

- install Git in linux : `sudo apt install -y git`
- Initialization configuration :
  - by command line :

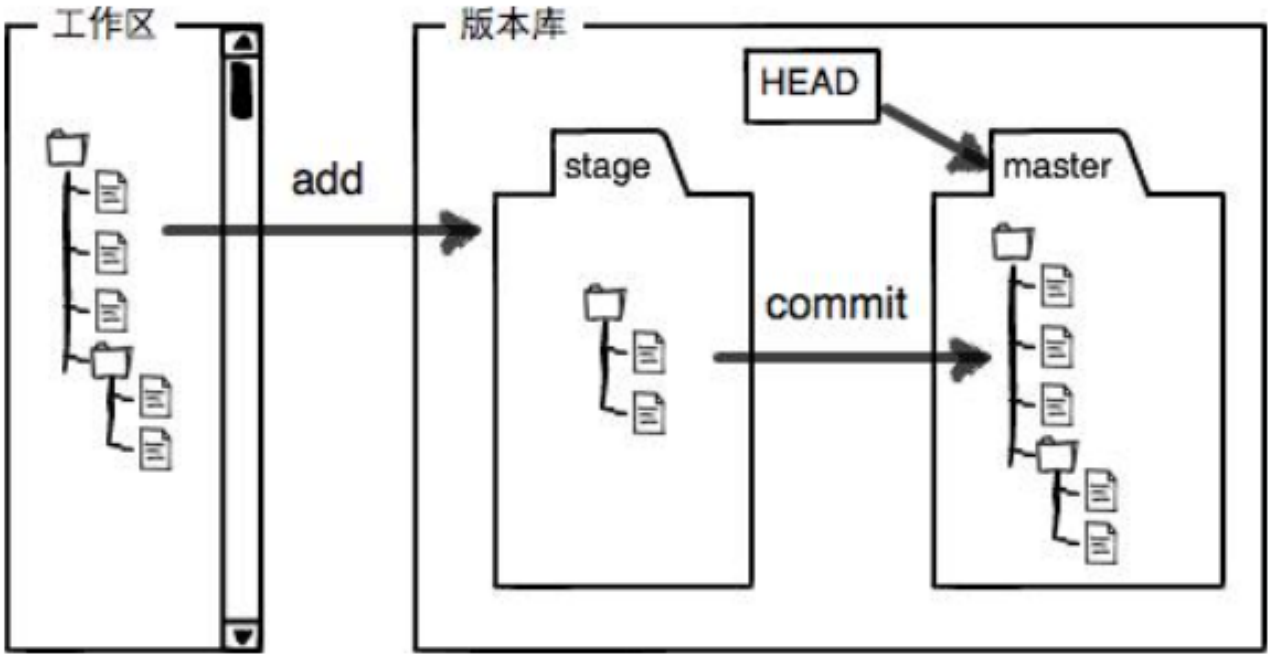
```
git config --global user.email "email@example.com"
git config --global user.name "Your Name"
```

  - by configuration file :
    create file `~/.gitconfig` or `~/.config/git/config`
    add below information

```
[user]
    email = "email@example.com"
    name = "Your Name"
```

Three important areas of Git

1. **workspace**: a folder in your computer which stores all files of your project
2. **stage**: a temporary area which is used to store your changes
3. **repository**: the place where all the information and files are stored



How to create a Git repository

1. use **git init** under a folder to create an empty repository, then the folder will be a git repository.
2. use **git clone *url*** to download an existed repository,
   - *url* could be a webseite or a local path

How to manage a local Git repository

After create or clone, a Git repository is now in your computer. The following command is the most frequently used to manage your Git repository

1. use **git add [*files..*]** to add some files from **workspace** into the **stage**
2. use **git commit [*files..*]** to add files from **stage** into **repository**
3. use **git status** to check the current status of the git repository
4. use **git log** to view all the previous commit
5. use **git checkout - - [*files..*]** to discard changes in workspace
6. more in official document

What is a branch

Branch is a special feature of Git. With branches, one can have several works in progress at the same time and all of them are independent. Also, you can merge two branches.

- use **git branch** to check all the branches
- use **git checkout -b [*name*]** to create branch
- use **git checkout [*name*]** to switch branch
- use **git merge [*name*]** to merge changes into the current branch.

How to manage a remote Git repository

1. use **git remote add [*name*] [*url*]** to add a remote repository through the *url* and name it as *name*
2. use **git pull [*name*] [*branch*]** to update the local git repository
3. use **git push [*name*] [*branch*]** to push local commit at *branch* to the remote repository

Reference about Git

1. MIT Git tutorial: Introduction to basic Git concepts and common commands with video.
2. Git document: long but useful for search.
3. Liao Xuefeng's tutorial: Chinese Git introduction with video.

Introduction of GCC

- GCC is short for GNU Compiler Collection. It is a widely used compiler for `C` and `C++`.
- Use `GCC` to compile `C` and g++ for `C++`.
- Basic command: `gcc xxx.c -o xxx`
- you can add arguments to enable some functions

Warning operation

- -**Wpedantic**: enable warnings about compiler or language compatibility.

```
// gcc -std=c99 -Wpedantic test.c
// warning: C++ style comments are not allowed in ISO C90
int main() {
    int a = ({ int b = 5; b; });
    return a;
}
```

- -**Wall**: enables warnings about constructions that some users consider questionable, and that are easy to avoid.
- -**Wextra**: enables extra warning that are not enabled by -Wall
- -**Werror**: Make all warnings into errors.
- more to see Options to Request or Suppress Warnings

Optimization operation

- **-O0,-O1,-O2,-O3** : different level of optimization.
- **-flto** : link-time optimizer.
- more to see Options That Control Optimization.

Some other useful arguments

- **-L**: specify path for finding header.
- **-std** : specify the compile standard.
- **-g** : add debug information into the executable files.
  - optimization option **-Og** is recommand if **-g** is used.

Introduction of GDB

- GDB is short for GNU Debugger.
- Add -**g** option to enable GDB, when compiling the source code.
- To start GDB, use **gdb** ***file*** , where file is the object file.

Basic usage of GDB

- **h** [*args..*]: print help for command args.
- **r** [*args..*]: start the program with args.
- **b** [*line number*] : set breakpoint.
- **c**: Continue program being debugged, after signal or breakpoint.
- **s**: Step program until it reaches a different source line.
- **n**: Step program, proceeding through subroutine calls.
- **p** [*vars*]: print variable.
- **layout** [*vars*]: change the layout of windows.
- **bt** Print backtrace of all stack frames.
- **f** Select and print a stack frame.

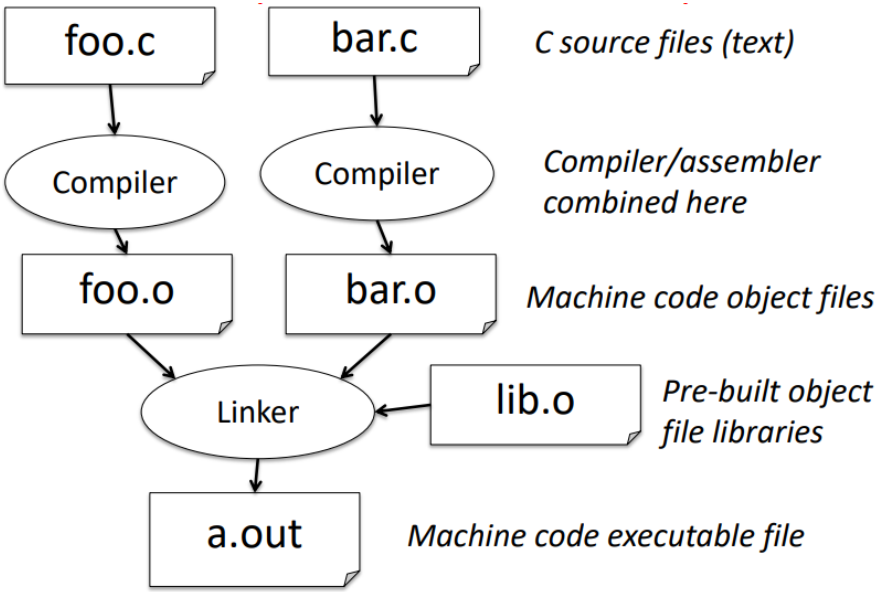
Reference for GCC and GDB

- Unix Programming Tools: a short but pratical introduction about GCC and GCB.
- Standford's GDB and Debugging: Beginner's guide to GDB with video.
- GDB quick reference: cheatsheet about GDB commands.

Link

Building process

- assemble: c syntax text code –> assemble code.
- compile: assemble code –> Executable and Linkable Format(ELF).
- **link: combines multiple ELF file into executable file or lib file.**



library

Libraries consists of **executable code** such as compiled functions and classes, and optional a collection of **header file**.

- Header file: such as `stdio.h`, used by developers to write code.
- Static library (executable code):
  - File with suffix `.a`
  - Totally integrated into executable programs.
  - Program can run without static library.
- Dynamic library (executable code):
  - File with suffix `.so`
  - Only integrated little symbolic information to executable program.
  - Program will look for the required symbols(function, variable) **when it is running**.
  - Program **can not** run without dynamic library.

Static library and static linking

Commands related to static linking

```
gcc -c <lib source> -o <lib object> # compile library
ar -rs <lib name> <lib object>      # generate library
gcc <source use lib> <lib name>     # use library
```

Advantage:

- fast
- program can run independently

Disadvantage:

- large files waste the memory
- combines all ELF together, even those not used code.

Dynamic library and dynamic linking

Commands related to dynamic linking

```
gcc -fpic -c <lib source> -o <lib object> # compile library
gcc -shared -o <lib name> <lib object> # generate library
gcc <source use lib> <lib name> # use library
```

Advantage:

- load needed modules when running, do not need to link all files together before running.
- easy to maintain separately
- decrease the size of executable files

Disadvantage:

- more complex
- may influence the performance

Useful commands about Link

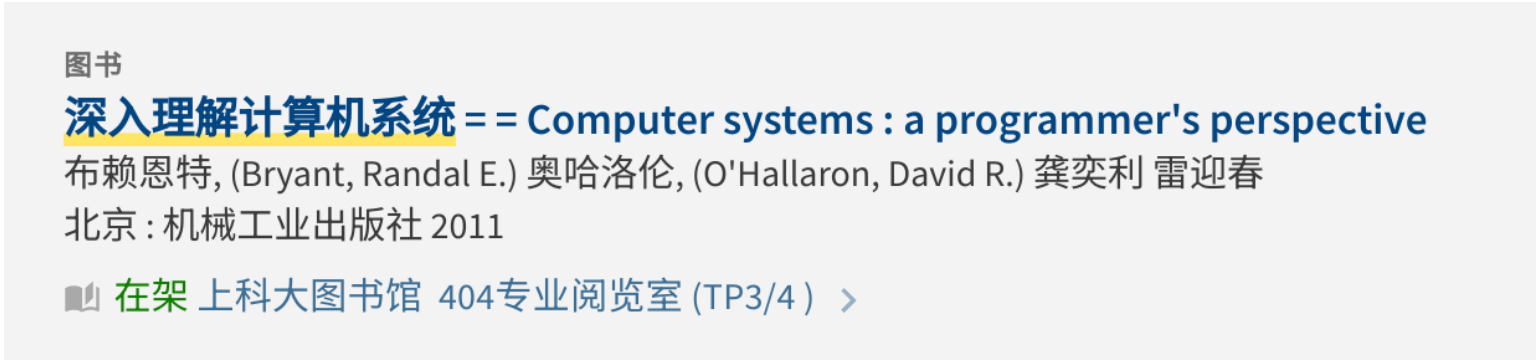
- **nm**: List symbol names in object file
- **readelf**: Parser and display information about ELF files
- **ldd**: Display shared library dependencies of a binary.

```
ubuntu@cloud-img:~$ ldd /usr/bin/gcc
        linux-vdso.so.1 (0x00007ffcd9fcd000)
        libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007fd11b5be000)
        /lib64/ld-linux-x86-64.so.2 (0x00007fd11b7f7000)
```

- **objdump**: View information about object files

Reference about link and static/dynamic libraries

- Classic Textbooks: **Computer Systems: A Programmer's Perspective**(CSAPP) chapter7 Linking


图书

深入理解计算机系统 = = Computer systems : a programmer's perspective

布赖恩特, (Bryant, Randal E.) 奥哈洛伦, (O'Hallaron, David R.) 龚奕利 雷迎春

北京 : 机械工业出版社 2011

在架 上科大图书馆 404专业阅览室 (TP3/4) >

- CMU lecture slides for CSAPP chapter7 Linking

Makefile introduction

What can a Makefile Do:

- **Automate Compilation:** Automatically compile only the parts of the project that have changed.
- **Reduce Repetitive Tasks:** Avoid manually typing long compiler commands for every file.
- **Manage Dependencies:** Keep track of which files depend on each other and ensure everything is up to date.

What is Makefile:

- A special **file** used by the CLI **make** to automate some process.
- It defines **a set of rules** for how to compile and link programs.
- Each rule contains **target, dependencies and build commands**.

Makefile's rule

Makefile Rule Syntax:

```
target: dependencies...
    build commands...
    ...
```

- **target**: File name or target name.
- **dependencies**: Files need for building target, can be empty.
- **build commands**: Extended shell scripts, could be multiple line.

How to use Makefile

1. create file named **Makefile** under any directory
2. write your rules in Makefile
3. type `make <target name>` in this directory

```
ubuntu@cloud-img:/tmp/make-example$ cat Makefile
hello:
        echo hello Makefile!
ubuntu@cloud-img:/tmp/make-example$ make hello
echo hello Makefile!
hello Makefile!
```

Pratical tips

- `build commands` must start with one tab, not space
- declare a non-filename target with keyword `.PHONY`
- type `make -n <target>` can only print commands but not execute

Makefile's variable

Basic Usage:

- The default type of makefile variables is **string**
- define a variable with `VarName := value`
- use a variable start with `$(VarName)`
- Variables can appear in **build commands** or **create new variables**.

Little Tips:

- define a variable with `VarName ?= value` to set a default value.
- shell variable can be used in Makefile

Example: branch var of cs110-discuss2

Reference about Makefile

- how-to-write-makefile: Chinese Makefile guide for beginners
- Learn Makefiles With the tastiest examples: English Makefile guide for beginners with video.
- Makefile manual: long but useful for search.

summarize

context:

- Linux system install and basic command line tools usage.
- Common Git commands: add, commit, log, status, clone, pull, push.
- GCC and GDB: how to compile, run and debug C in Linux.
- Brief introduction about static/dynamic link and library.
- Pratical Makefile guidence.
- Demonstrate with a Git repository which include all topics.

Hope:

- Read the friendly manual.
- Search the friendly webseite.
- Ask the friendly LLM.