NEMU框架选讲(1): 编译运行

王慧妍
why@nju.edu.cn

南京大学 计算机科学与技术系 计算机软件研究所

提醒

PA1：

Deadline：2022.10.9 23:59:59

Lab1：

Deadline：2022.10.16 23:59:59

OJ今早更新上线，之前提交的同学麻烦重新提交

本讲概述

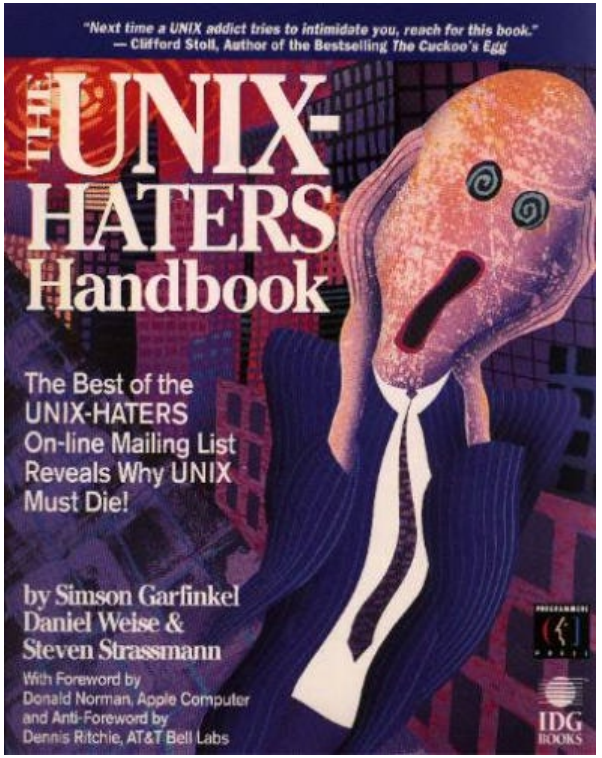
- Git，GitHub与代码仓库
  - Git选讲
  - Git在实验中的应用

- 项目的构建
  - Lab
  - NEMU
  - AbstractMachine

Git，GitHub和代码仓库

The UNIX Hater's Handbook (and Beyond)

- 写于1994年
  - Simson Garfinkel 的主页有电子版
  - 说有道理也有道理说没道理也没道理



1 **Unix**

The World's First Computer Virus

Unix Myths

Unix Myths

Drug users lie to themselves. "Pot won't make me stupid." "I'm just going to try crack once." "I can stop anytime that I want to." If you are in the market for drugs, you'll hear these lies.

Unix has its own collection of myths, as well as a network of dealers pushing them. Perhaps you've seen them before:

1. It's standard.
2. It's fast and efficient.
3. It's the right OS for all purposes.
4. It's small, simple, and elegant.
5. Shellscripts and pipelines are great way to structure complex problems and systems.
6. It's documented online.
7. It's documented.
8. It's written in a high-level language.
9. X and Motif make Unix as user-friendly and simple as the Macintosh.
10. Processes are cheap.
11. It invented:
    - the hierarchical file system
    - electronic mail
    - networking and the Internet protocols
    - remote file access
    - security/passwords/file protection
    - finger
    - uniform treatment of I/O devices.
12. It has a productive programming environment.
13. It's a modern operating system.
14. It's what people are asking for.
15. The source code:
    - is available
    - is understandable
    - you buy from your manufacturer actually matches what you are running.

You'll find most of these myths discussed and debunked in the pages that follow.

UNIX哲学

- *Keep it simple, stupid.* (KISS)
  - *Everything* is a file and *pipeline* programs to work together

- 一个命令只做“一件事”
  - 从stdin输入（`prinf`）
  - 向stdout输出（`scanf`）
  - 使用参数控制行为（`int main (int argc, char * argv[]);`）
- 命令的输入和输出都是人类 + 机器均可读的文本
  - `find .`
  - `wc -l a.txt b.txt`
- 把命令的输入/输出连接起来 (管道) 协作完成任务
  - `find . | grep '\.cpp$' | xargs cat | wc -l`

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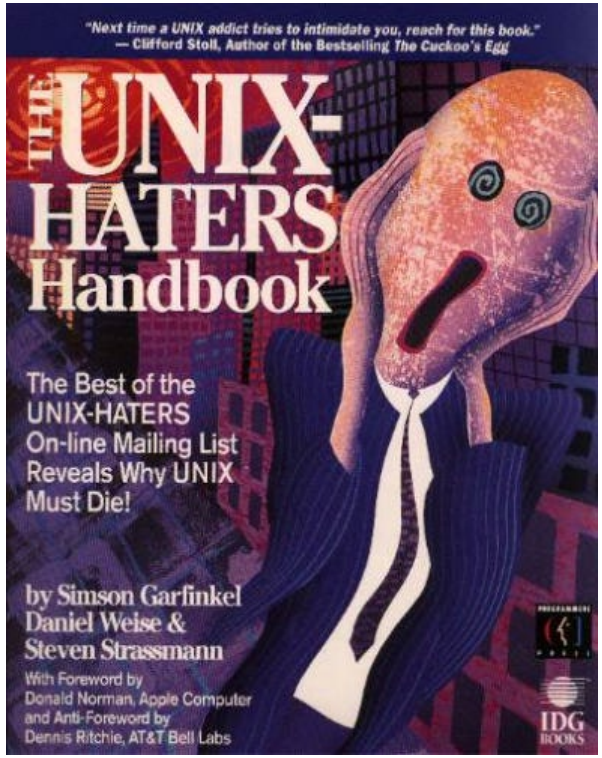

- 至少指出了 UNIX 的一些缺陷
  - user friendly
  - 命令行/系统工具的缺陷
    - "`rm`" is forever
  - 手册的冗长
    - `man wc`
    - `man gcc` (26000+ 行)

1 **Unix**

The World's First Computer Virus

一个小例子

- rm -rf XX
  - 强制删除
  - 如果文件名叫-rf呢?
    - **rm -rf?**
    - **rm -rf -rf?**

```
$ ls -l
total 0
-rw-r--r-- 1 why why 0 Aug 25 18:10 -rf
$ rm -rf
$ ls -l
total 0
-rw-r--r-- 1 why why 0 Aug 25 18:10 -rf
$ rm -rf -rf
$ ls -l
total 0
-rw-r--r-- 1 why why 0 Aug 25 18:10 -rf
$
```

The UNIX Hater's Handbook (and Beyond)

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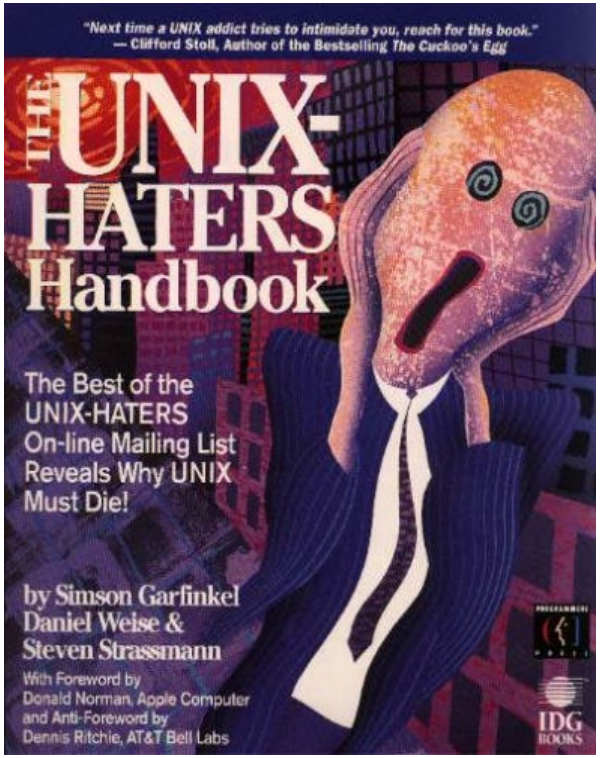


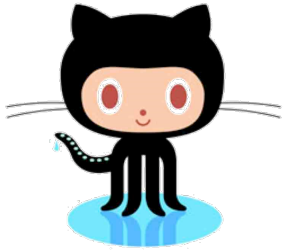
- 至少指出了 UNIX 的一些缺陷
  - user friendly
  - 命令行/系统工具的缺陷
  - 手册的冗长

- 但今天 UNIX/Linux 已经成熟多了!
  - `man`
  - `tldr`

The Community Way

开源社区 (百度百科)：根据相应的开源软件许可证协议公布软件源代码的网络平台，同时也为网络成员提供一个自由学习交流的空间。

- 从GitHub获取代码
  - 传统工具链 + “现代”编程体验
    - ~~有的时候网络不太靠谱~~



github
SOCIAL CODING

```
git clone -b 2022 git@github.com:NJU-ProjectN/ics-pa.git ics2022
git clone https://github.com/NJU-ProjectN/ics-workbench
```

GitLab

gitee

https://git.nju.edu.cn/

The Community Way (cont'd)

GitHub is a development platform inspired by the way you work. From open source to business, you can host and review code, manage projects, and build software alongside 50 million developers.

- 无所不能的代码聚集地
  - 有整个计算机系统世界的代码
    - 硬件、操作系统、分布式系统、库函数、应用程序……
- 学习各种技术的最佳平台
  - 海量的文档、学习资料、博客（新世界的大门）
    - 提供友好的搜索（例子：**awesome C**）

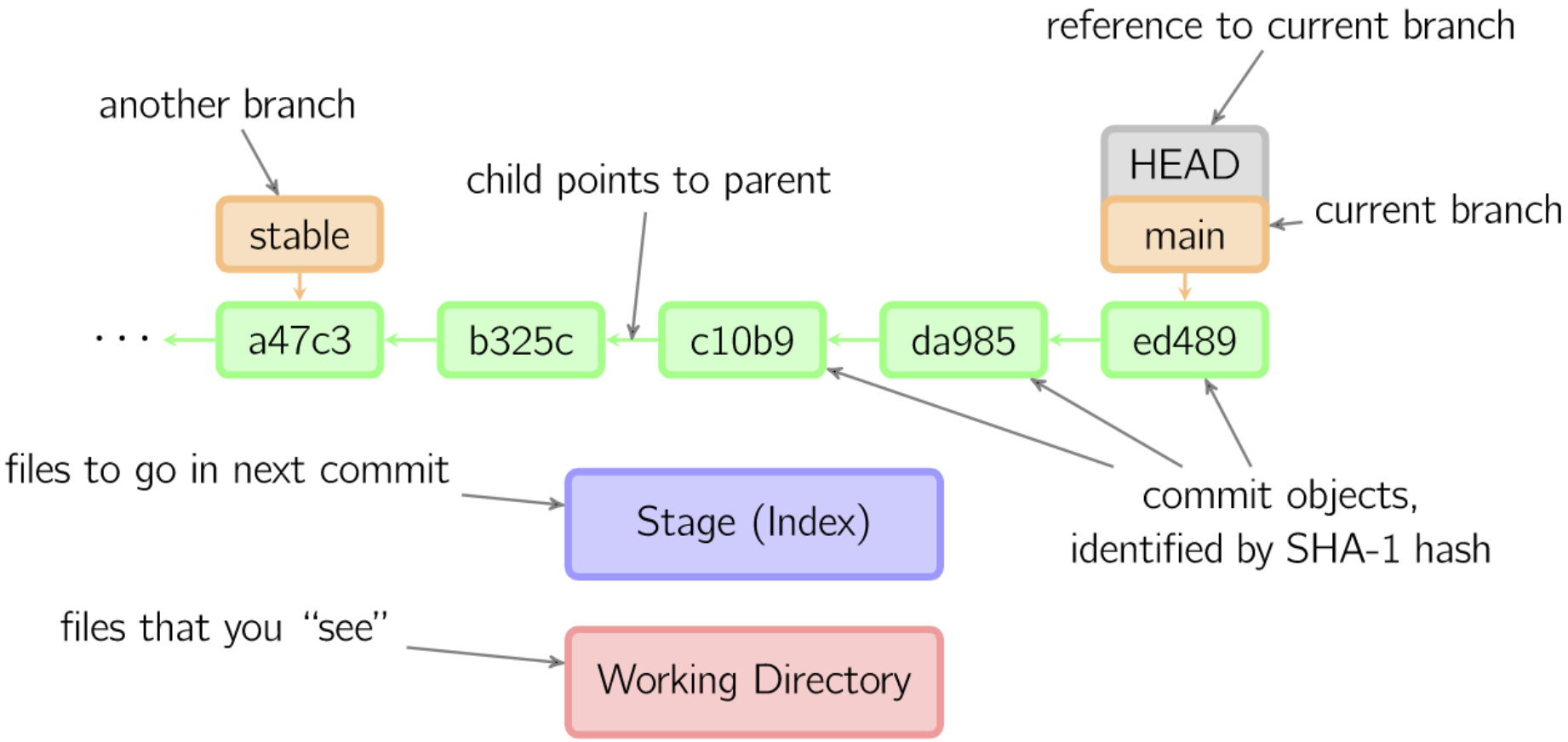
学习Git?

```
git clone -b 2021 https://github.com/NJU-ProjectN/ics-pa ics2021
```

内心独白：又要学新东西，我拒绝==

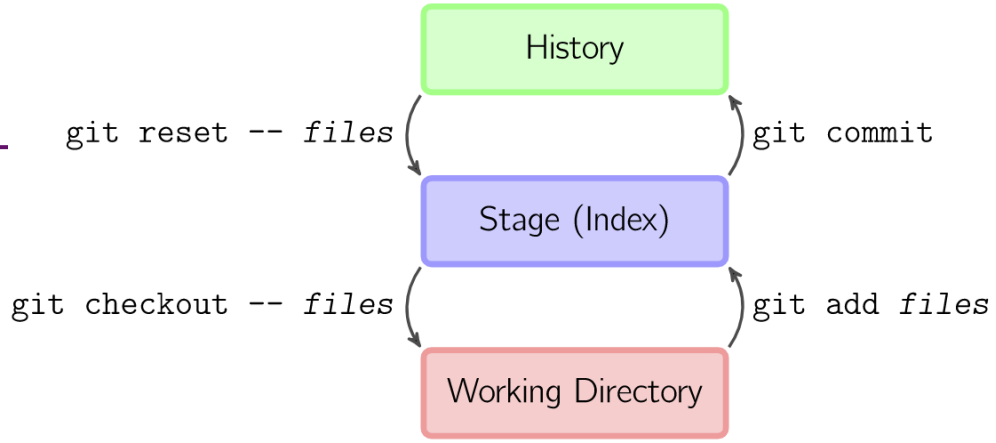
- RTFM?STFW!
  - 百度：得到一堆不太靠谱的教程
  - 大家已经见识过开源社区的力量了
    - A Visual Git Reference
      - 英文、中文、日文……
    - 好的文档是存在的
      - 还记得 tldr 吗?

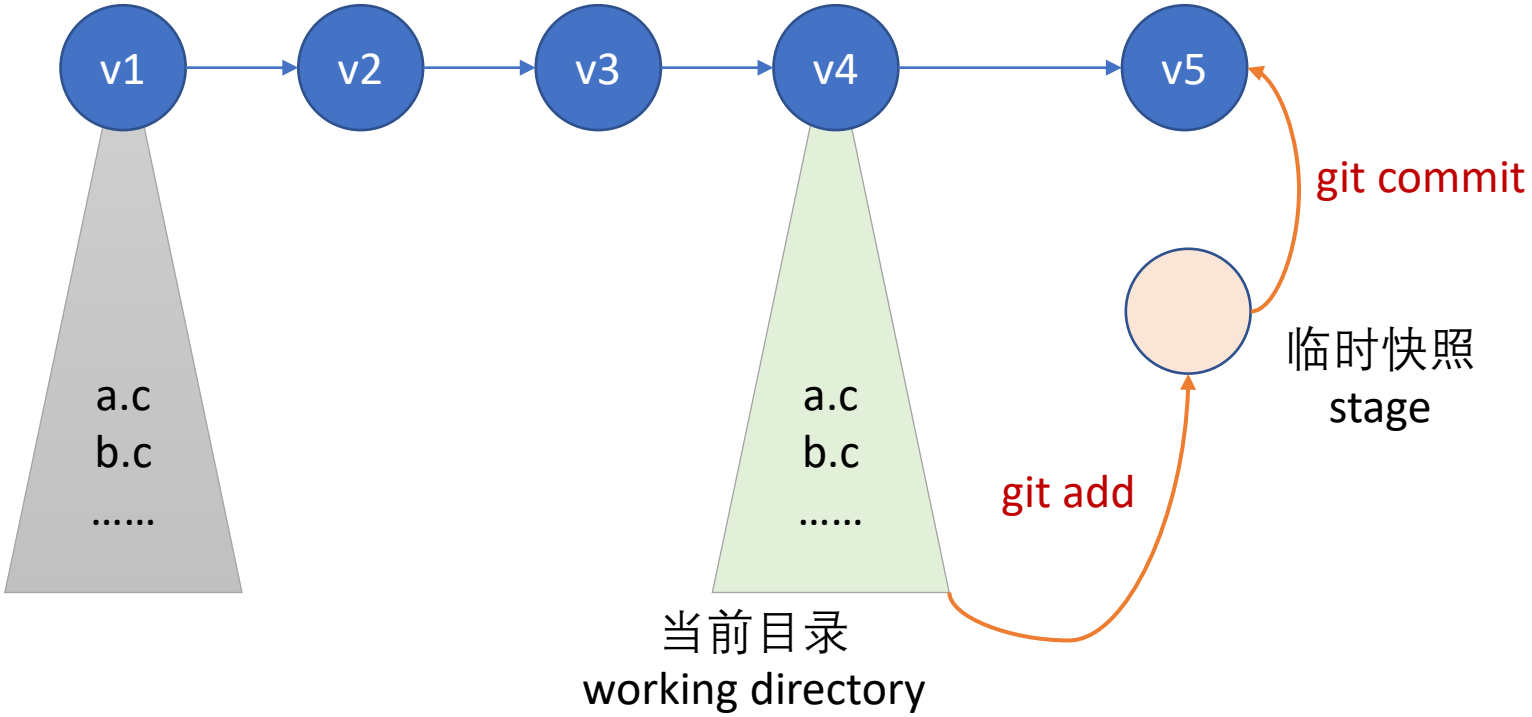
A Visual Git Reference



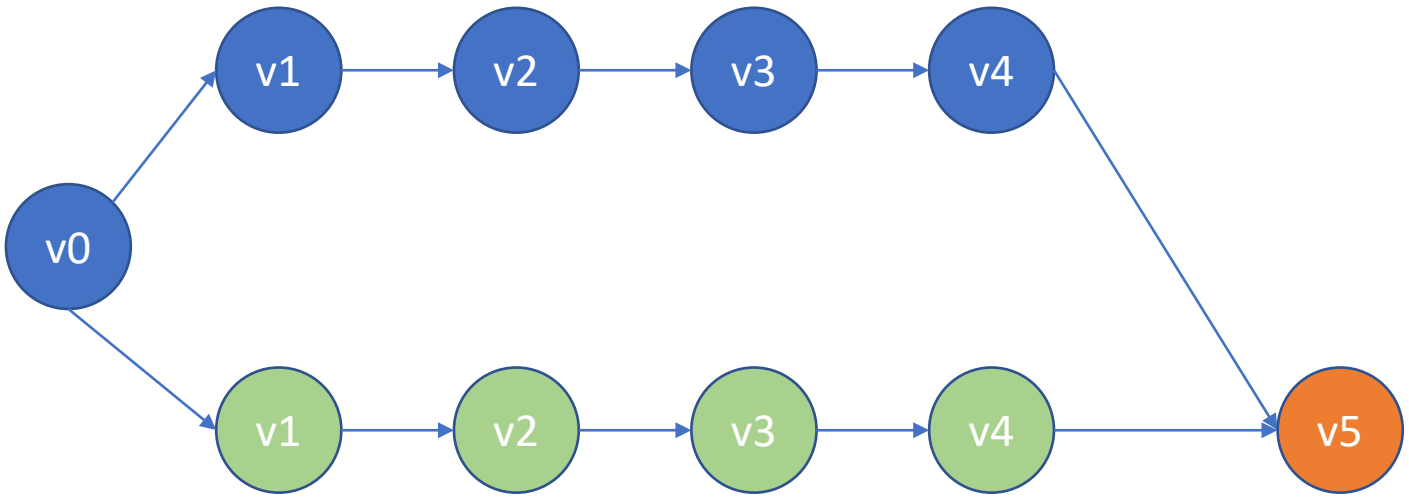

```
commit 8738b7b32e71a78f5b73376dc664780dd16800eb (HEAD -> pa1)
Author: tracer-ics2020 <tracer@njuics.org>
Date:   Thu Aug 19 18:27:15 2021 +0800
```

Git

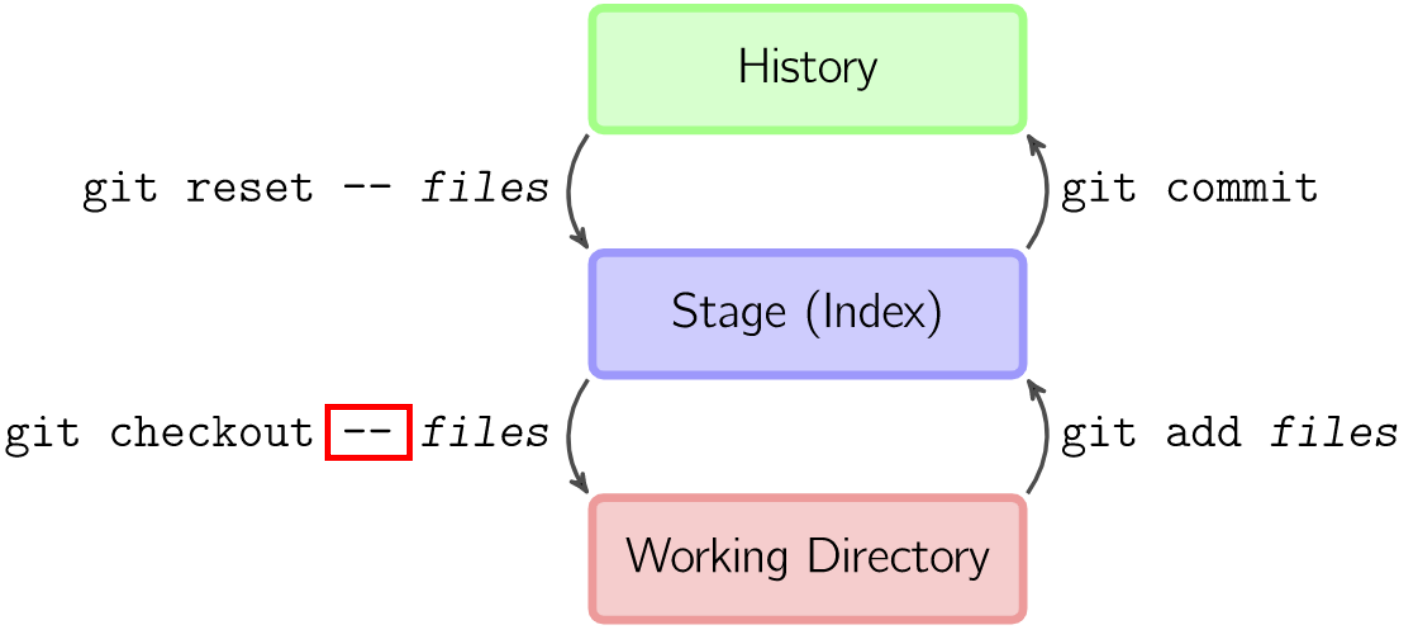

History
git reset -- files
git commit
Stage (Index)
git checkout -- files
git add files
Working Directory


v1
v2
v3
v4
v5
a.c
b.c
.....
a.c
b.c
.....
git commit
临时快照
stage
git add
当前目录
working directory

Git：分布式版本控制系统



A Visual Git Reference (cont'd)

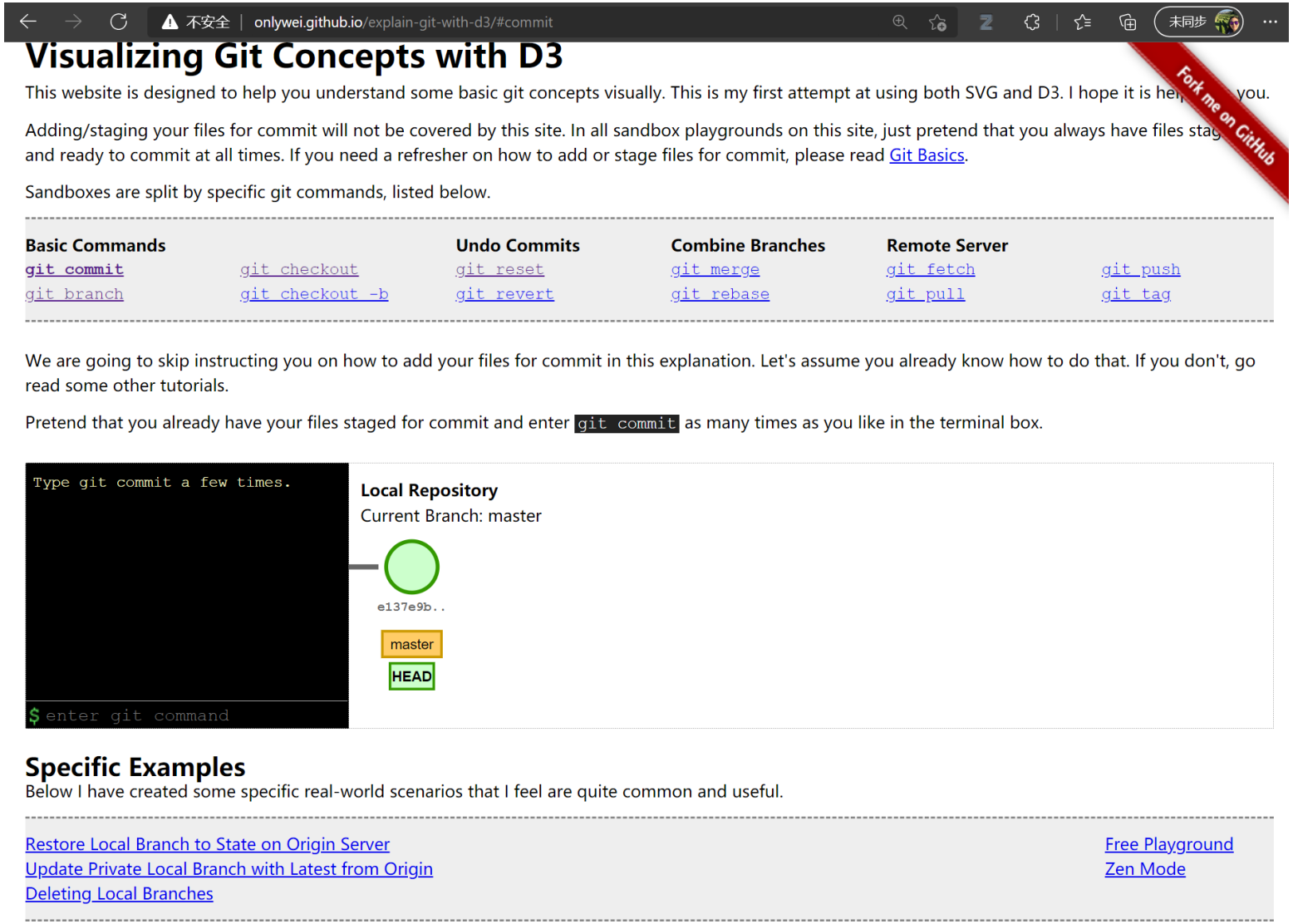



```
$ ls -l
total 0
-rw-r--r-- 1 why why 0 Aug 25 18:10 -rf
$ rm -- -rf
$ ls -l
total 0
```

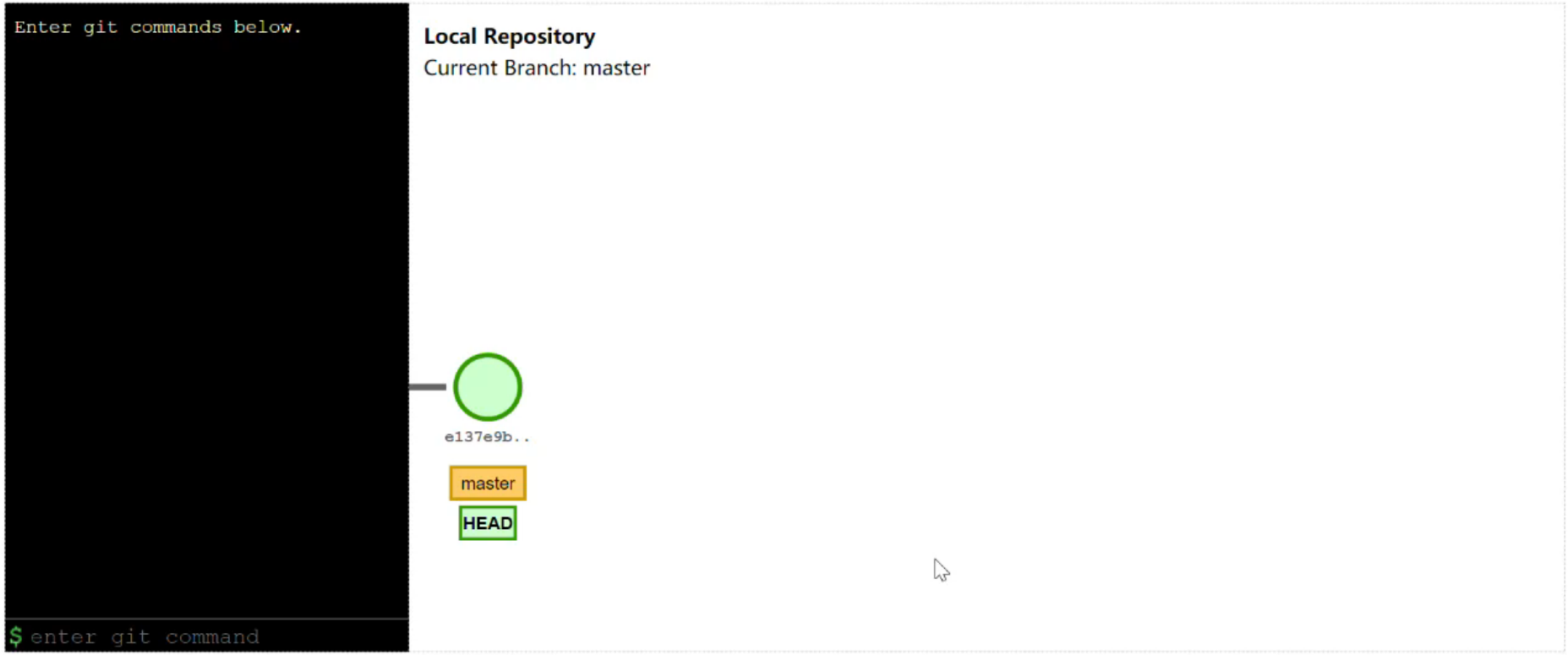
一些Comments

- 有趣的 “--”
  - UNIX 的设计缺陷 (UGH 中点名批评)
    - 虽然是编程语言，但 Shell 更贴近自然语言
  - 也有很多 corner cases
    - 如果有一个文件叫 “-rf”……怎么删除它？？？
    - best practice: 文件名不以 “-” 开头、不含空格/符号……
- 体验 Git
  - 创建一个新的 repo，自由探索
    - 为什么 “预计完成时间 XX 小时” 是骗人的?
      - 预计完成时间是假设你在大一开始就用 Git 的
  - Visualizing Git Concepts with D3

Visualizing Git Concepts with D3



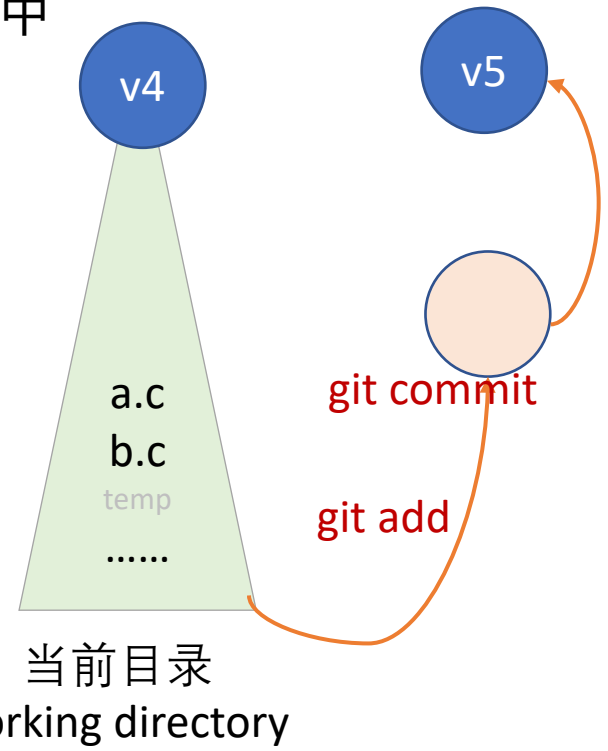
Visualizing Git Concepts with D3



一些Comments (cont'd)

- 我们使用了“白名单” .gitignore文件
  - 只在Git repo里管理.c, .h和Makefile
    - 基本原则：一切生成的文件都不放在Git仓库中

```
*           # 忽略一切文件
!*/         # 除了目录
!*.c        # .c
!*.h        # ...
!Makefile*
!.gitignore
```



- 为什么ls看不到这个文件?
  - 怎么还有一个.git

```
git clone -b 2021 https://github.com/NJU-ProjectN/ics-pa ics2021
```

获取PA代码

```
git clone -b 2022 git@github.com:NJU-ProjectN/ics-pa.git ics2022
```

- 获取来自github的一整个历史

提交脚本

- make submit会下载执行http://jyywiki.cn/static/submit.sh
  - Makefile

```
submit:
   git gc
   STUID=$(STUID) STUNAME=$(STUNAME) bash -c "$$(curl -s
http://why.ink:8080/static/submit.sh)"
```

```
bash -c "$(curl -s http://why.ink:8080/static/submit.sh)"
```

- 我们做了什么?

```
why@why-VirtualBox:~/Documents/ICS2022/ics2022$ curl -s http://why.ink:8080/static/submit.sh
COURSE=ICS2022
MODULE=$(git rev-parse --abbrev-ref HEAD | tr '[a-z]' '[A-Z]')
FILE=/tmp/upload.tar.bz2
tar caf "$FILE" ".git" $(find . -maxdepth 2 -name "*.pdf") && \
  curl -F "token=$TOKEN" \
       -F "course=$COURSE" \
       -F "module=$MODULE" \
       -F "file=@$FILE" \
       http://why.ink:8080/upload
```

提交脚本

- make submit会下载执行http://why.ink:8080/static/submit.sh

```
bash -c "$(curl -s http://why.ink:8080/static/submit.sh)"
```

```
$ git branch
  master
* pa0
  pa1
$ git rev-parse --abbrev-ref HEAD
pa0
$ git checkout pa1
Switched to branch 'pa1'
$ git rev-parse --abbrev-ref HEAD
pa1
```

PA1?PA2?

```
# submit.sh (服务器)
COURSE=ICS2022
MODULE=$(git rev-parse --abbrev-ref HEAD | tr '[a-z]' '[A-Z]’)
FILE=/tmp/upload.tar.bz2

tar caf "$FILE" "$NAME/.git" $(find $NAME -maxdepth 2 -name "*.pdf") && \
    curl -F “token=$TOKEN"
         -F "course=$COURSE"
         -F "module=$MODULE" \
         -F "file=@$FILE" http://why.ink:8080/upload
```

OJ得到的是.git

- .git包含了OJ想知道的一切

```
./.git
./.git/objects
./.git/objects/info
./.git/objects/pack
./.git/hooks
./.git/info
./.git/info/exclude
./.git/HEAD
./.git/branches
./.git/description
./.git/refs
./.git/refs/heads
./.git/refs/tags

./.git/config # 配置
```

Git追踪

- 另一段神秘代码 (来自 Makefile.lab)

```
git:
	@git add $(shell find . -name "*.c") \
	    $(shell find . -name "*.h") -A --ignore-errors
	@while (test -e .git/index.lock); do sleep 0.1; done
	@(hostnamectl && uptime) | \
	    git commit -F - -q --author=tracer-nju <tracer@nju.edu.cn>
--no-verify --allow-empty   @sync
```

- 在每次 make 执行时
  - git 目标都会被执行
  - 将 .c 和 .h 添加、强制提交到 Git repo

```
$ hostnamectl
   Static hostname: why-VirtualBox
         Icon name: computer-vm
           Chassis: vm
        Machine ID: 22e7c7921a0a437bb1817612c8ab2cce
           Boot ID: 51bcab304005479b8dcec150413ee8bf
    Virtualization: oracle
  Operating System: Ubuntu 21.04
            Kernel: Linux 5.11.0-34-generic
      Architecture: x86-64
$
$ uptime
 17:25:29 up  1:45,  1 user,  load average: 0.11, 0.09, 0.02
```

Git追

```
6  GITFLAGS = -q --author='tracer-ics2021 <tracer@njuics.org>' --no-verify --allow-empty
7
8  # prototype: git_commit(msg)
9  define git_commit
10   -@git add $(NEMU_HOME)/.. -A --ignore-errors
11   -@while (test -e .git/index.lock); do sleep 0.1; done
12   -@(echo "> $(1)" && echo $(STUID) && hostnamectl && uptime) | git commit -F - $(GITFLAGS)
13   -@sync
14 endef
```

```
commit 2662595b8712e2247fd1a92b5cb8b9103c9fc01b
Author: tracer-ics2021 <tracer@njuics.org>
Date:   Thu Sep 16 12:07:21 2021 +0800

    >  compile
    ky2107911
       Static hostname: why-VirtualBox
             Icon name: computer-vm
               Chassis: vm
            Machine ID: 22e7c7921a0a437bb1817612c8ab2cce
               Boot ID: 6cbe073460244ae0ad90966cdbbe5961
        Virtualization: oracle
      Operating System: Ubuntu 21.04
                Kernel: Linux 5.11.0-34-generic
          Architecture: x86-64
     12:07:21 up  2:40,  2 users,  load average: 0.23, 0.23, 0.19

commit 713801b46b12063c27db811bd61a9b935395cd35
Author: tracer-ics2021 <tracer@njuics.org>
Date:   Thu Sep 16 12:06:39 2021 +0800

    >  run
    ky2107911
       Static hostname: why-VirtualBox
             Icon name: computer-vm
               Chassis: vm
            Machine ID: 22e7c7921a0a437bb1817612c8ab2cce
               Boot ID: 6cbe073460244ae0ad90966cdbbe5961
        Virtualization: oracle
      Operating System: Ubuntu 21.04
                Kernel: Linux 5.11.0-34-generic
          Architecture: x86-64
     12:06:39 up  2:39,  2 users,  load average: 0.46, 0.26, 0.20
```

这是什么？

- 对抄袭代码的一种威慑
  - 如何抓抄袭
    - 旧方法；但至今仍在使用
  - Git 追踪是 “一劳永逸的新方法”
    - 透过它，我们看到南大学子的人生百态

知乎 首发于 软件工程技术研究漫谈

代码抄袭：那些让985学生沉默，211学生流泪的真相

蒋炎岩
计算机科学与技术博士

2,221 人赞同了该文章

> 这是我们在TURC’18 (SIGCSE China)的论文Needle: Detecting Code Plagiarism on Student Submissions [1]的科普版本。

“我们不生产代码，我们只是互联网的搬运工”——佚名

在平均学历是985的知乎，考不上个好学校都没脸出来冒泡。然而，到底是我们上了大学，还是大学上了我们？这篇文章来谈谈一个985学生知道了会沉默，211学生知道了会流泪的真相：广泛存在的抄作业问题。我想大部分读者朋友们看到这里的感受都是：中枪了。

你还记得上大学的时候，把“大腿”的作业拿来抄抄改改，然后去打游戏的日子吗？或者如果你就是同学们心目中的“大腿”，有没有慷慨相助同学们的经历？也许这类事情的确没有发生在你身上，但在计算机学科里，我们严肃的研究发现：

- 某985大学的一次实验大作业中，若不对代码抄袭控制，有超过82%的同学涉嫌拷贝代码(抄袭或被抄袭)，并且抄袭者会对代码做出不同程度的修改。大家也都知道，计算机专业课程光说不练课可就白上了，也就是说，在一届同学中有超过4/5这门课都白上了。考虑到还有同学选择不交作业，这个比例还会再高一些……
- 在一所985大学的一门课程中，即便使用了抄袭检测工具、制定严格的惩罚措施、给有困难的同学提供“诚信分”，一门课程整个学期下来，依然有约20%的同学涉嫌拷贝代码。甚至有同学被逮到以后还会再抄、再被逮到以后再抄代码，铤而走险，屡教不改。

(以上结论仅针对我们调研的编程实验有效，而且导致同学们抄代码的原因是多种多样的，整体的代码抄袭情况我们尚未完全统计。)

这是什么?

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  - Git 追踪是 “一劳永逸的新方法”
    - 透过它，我们看到南大学子的人生百态
- 记得 academic integrity
  - 我们留了足够多的分数给努力尝试过的同学通过
- 未来可能有终极加强版

小结：现代化的项目管理方式

- Git: 代码快照管理工具
  - 是一种 “可持久化数据结构”
  - 拓展阅读：Pro Git
- 框架代码中的两处非常规 Git 使用
  - 提交脚本
    - 仅上传 .git；在服务器执行 git reset
    - 减少提交大小 (仅源文件)
  - Git 追踪
    - 编译时强制提交，获取同学编码的过程
- 思考题：如何管理自己的代码快照?
  - 提示：分支/HEAD/... 只是指向快照的指针 (references)

项目构建

Make工具

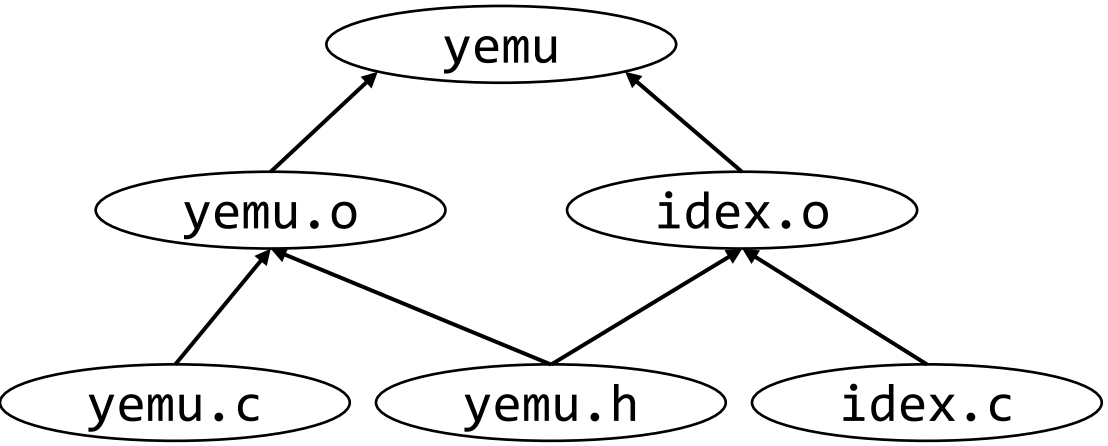
- 回顾：YEMU 模拟器

- Makefile 是一段 “declarative” 的代码
  - 描述了构建目标之间的依赖关系和更新方法

```
.PHONY: run clean test

CFLAGS = -Wall -Werror -std=c11 -O2
CC = gcc
LD = gcc

yemu: yemu.o idex.o
    $(LD) $(LDFLAGS) -o yemu yemu.o idex.o

yemu.o: yemu.c yemu.h
    $(CC) $(CFLAGS) -c -o yemu.o yemu.c

idex.o: idex.c yemu.h
    $(CC) $(CFLAGS) -c -o idex.o idex.c

run: yemu
    @./yemu

clean:
    rm -f test yemu *.o

test: yemu
    $(CC) $(CFLAGS) -o test idex.o test.c && ./test
```

Makefile

- make
  - gcc -Wall -Werror -std=c11 -O2 -c -o yemu.o yemu.c
  - gcc -Wall -Werror -std=c11 -O2 -c -o idex.o idex.c
  - gcc -o yemu yemu.o idex.o



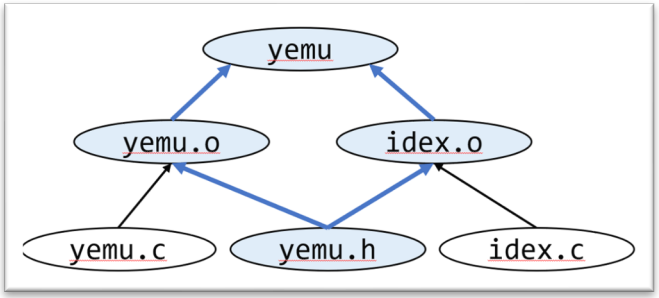

```
1  .PHONY: run clean test
2
3  CFLAGS = -Wall -Werror -std=c11 -O2
4  CC = gcc
5  LD = gcc
6
7  yemu: yemu.o idex.o
8      $(LD) $(LDFLAGS) -o yemu yemu.o idex.o
9
10 yemu.o: yemu.c yemu.h
11     $(CC) $(CFLAGS) -c -o yemu.o yemu.c
12
13 idex.o: idex.c yemu.h
14     $(CC) $(CFLAGS) -c -o idex.o idex.c
15
16 run: yemu
17     @./yemu
18
19 clean:
20     rm -f test yemu *.o
21
22 test: yemu
23     $(CC) $(CFLAGS) -o test idex.o test.c && ./test
```

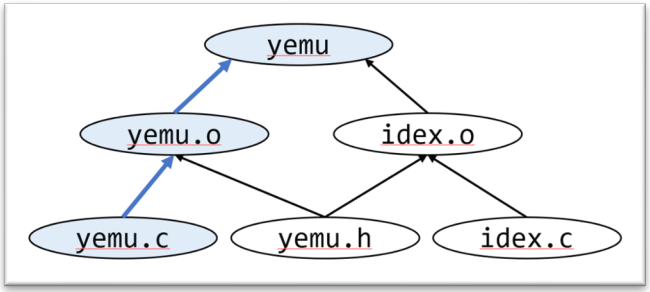
Make工具

- 回顾：YEMU 模拟器

- Makefile 是一段 “declarative” 的代码
  - 描述了构建目标之间的依赖关系和更新方法

```
$ make
gcc -Wall -Werror -std=c11 -O2 -c -o yemu.o yemu.c
gcc -Wall -Werror -std=c11 -O2 -c -o idex.o idex.c
gcc  -o yemu yemu.o idex.o
$ make
make: 'yemu' is up to date.
```





- `make -j8`

Make工具

- 回顾：YEMU 模拟器

- Makefile 是一段 “declarative” 的代码
  - 描述了构建目标之间的依赖关系和更新方法
  - 有用的编译选项
    - -nB、-j
  - 同时也是和 Shell 结合紧密的编程语言
    - 能够生成各种字符串
    - 支持 “元编程” (#include, #define, …)

Lab代码的构建

- 顶层 (top-level) Makefile:

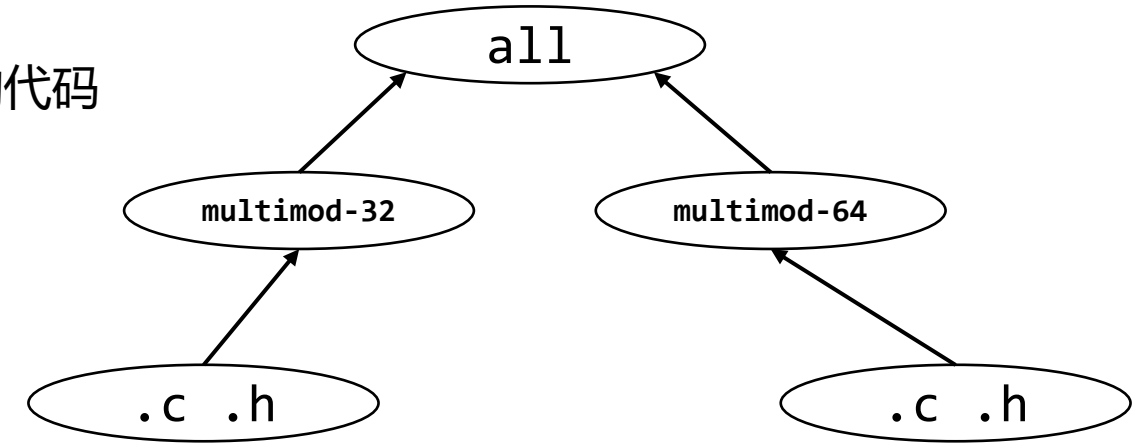
```
# := -> C #define
   NAME := $(shell basename $(PWD))
export MODULE := Lab1

# 变量 -> 字面替换
all: $(NAME)-64 $(NAME)-32

# include -> C #include
include ../Makefile
```

```
1  # **DO NOT MODIFY**
2
3  ifeq ($(NAME),)
4  $(error Should make in each lab's directory)
5  endif
6
7  SRCS   := $(shell find . -maxdepth 1 -name "*.c")
8  DEPS   := $(shell find . -maxdepth 1 -name "*.h") $(SRCS)
9  CFLAGS += -O1 -std=gnu11 -ggdb -Wall -Werror -Wno-unused-result -Wno
   -unused-value -Wno-unused-variable
10
11 .PHONY: all git test clean commit-and-make
12
13 .DEFAULT_GOAL := commit-and-make
14 commit-and-make: git all
15
16 $(NAME)-64: $(DEPS) # 64bit binary
17   gcc -m64 $(CFLAGS) $(SRCS) -o $@ $(LDFLAGS)
18
19 $(NAME)-32: $(DEPS) # 32bit binary
20   gcc -m32 $(CFLAGS) $(SRCS) -o $@ $(LDFLAGS)
21
22 $(NAME)-64.so: $(DEPS) # 64bit shared library
23   gcc -fPIC -shared -m64 $(CFLAGS) $(SRCS) -o $@ $(LDFLAGS)
24
25 $(NAME)-32.so: $(DEPS) # 32bit shared library
26   gcc -fPIC -shared -m32 $(CFLAGS) $(SRCS) -o $@ $(LDFLAGS)
27
28 clean:
29   rm -f $(NAME)-64 $(NAME)-32 $(NAME)-64.so $(NAME)-32.so
30
31 include ../Makefile.lab
```


Applications
Lab1: 大整数运算 - Mozill...
Terminal - why@debian...
18:11
why
Terminal - why@debian: ~/ICS_teach/ics-workbench/multimod
File Edit View Terminal Tabs Help
$ ls
main.c Makefile multimod-32 multimod-64 multimod.c
$ vim Makefile
$ vim Makefile

Lab代码的构建 (cont'd)

- 构建目标
  - 总目标
    - `.DEFAULT_GOAL := commit-and-make`
    - `commit-and-make: git all` (all 在顶层 Makefile 中定义)
  - 可执行文件
    - `multimod-64: gcc -m64`
    - `multimod-32: gcc -m32`
  - 共享库 (之后的 lab 使用)
    - `multimod-64.so: gcc -fPIC -shared -m64`
    - `multimod-32.so: gcc -fPIC -shared -m32`
  - `clean`
    - 删除构建的代码



NEMU代码构建

- Makefile 真复杂
  - 放弃?

```
$ make
+ CC src/nemu-main.c
+ CC src/isa/riscv32/difftest/dut.c
+ CC src/isa/riscv32/system/intr.c
+ CC src/isa/riscv32/system/mmu.c
+ CC src/isa/riscv32/init.c
+ CC src/isa/riscv32/logo.c
+ CC src/isa/riscv32/reg.c
+ CC src/isa/riscv32/instr/decode.c
+ CC src/device/io/map.c
+ CC src/device/io/mmio.c
+ CC src/device/io/port-io.c
+ CC src/engine/interpreter/hostcall.c
+ CC src/engine/interpreter/init.c
+ CC src/cpu/difftest/dut.c
+ CC src/cpu/cpu-exec.c
+ CC src/monitor/sdb/watchpoint.c
+ CC src/monitor/sdb/sdb.c
+ CC src/monitor/sdb/expr.c
+ CC src/monitor/monitor.c
+ CC src/utils/log.c
+ CC src/utils/rand.c
+ CC src/utils/state.c
+ CC src/utils/timer.c
+ CC src/memory/paddr.c
+ CC src/memory/vaddr.c
+ LD /home/why/Documents/ICS2021/ics2021/nemu/build/riscv32-nemu-interpre
$
```

```
1  # Sanity check
2  ifeq ($(wildcard $(NEMU_HOME)/src/nemu-main.c),)
3    $(error NEMU_HOME=$(NEMU_HOME) is not a NEMU repo)
4  endif
5
6  # Include variables and rules generated by menuconfig
7  -include $(NEMU_HOME)/include/config/auto.conf
8  -include $(NEMU_HOME)/include/config/auto.conf.cmd
9
10 remove_quote = $(patsubst "%",%,$(1))
11
12 # Extract variabls from menuconfig
13 GUEST_ISA ?= $(call remove_quote,$(CONFIG_ISA))
14 ENGINE ?= $(call remove_quote,$(CONFIG_ENGINE))
15 NAME    = $(GUEST_ISA)-nemu-$(ENGINE)
16
17 # Include all filelist.mk to merge file lists
18 FILELIST_MK = $(shell find ./src -name "filelist.mk")
19 include $(FILELIST_MK)
20
21 # Filter out directories and files in blacklist to obtain the final set of source files
22 DIRS-BLACKLIST-y += $(DIRS-BLACKLIST)
23 SRCS-BLACKLIST-y += $(SRCS-BLACKLIST) $(shell find $(DIRS-BLACKLIST-y) -name "*.c")
24 SRCS-y += $(shell find $(DIRS-y) -name "*.c")
25 SRCS = $(filter-out $(SRCS-BLACKLIST-y),$(SRCS-y))
26
27 # Extract compiler and options from menuconfig
28 CC = $(call remove_quote,$(CONFIG_CC))
29 CFLAGS_BUILD += $(call remove_quote,$(CONFIG_CC_OPT))
30 CFLAGS_BUILD += $(if $(CONFIG_CC_LTO),-flto,)
31 CFLAGS_BUILD += $(if $(CONFIG_CC_DEBUG),-ggdb3,)
32 CFLAGS_BUILD += $(if $(CONFIG_CC_ASAN),-fsanitize=address,)
33 CFLAGS  += $(CFLAGS_BUILD) -D__GUEST_ISA__=$(GUEST_ISA)
34 LDFLAGS += $(CFLAGS_BUILD)
35
36 # Include rules for menuconfig
37 include $(NEMU_HOME)/scripts/config.mk
38
39 ifdef CONFIG_TARGET_AM
40 include $(AM_HOME)/Makefile
41 LINKAGE += $(ARCHIVES)
42 else
43 # Include rules to build NEMU
44 include $(NEMU_HOME)/scripts/native.mk
45 endif
~
~
~
~
~
~
~
~/Documents/ICS2021/ics2021/nemu/Makefile[1]                    [make] un
```

还是尝试去读一下

管理 控制 视图 热键 设备 帮助

```
why@why-VirtualBox:~/Documents/ICS2021/ics2021/nemu$ ls
build  configs  include  Kconfig  Makefile  README.md  resource  scripts  src  tools
why@why-VirtualBox:~/Documents/ICS2021/ics2021/nemu$ vim Kconfig
why@why-VirtualBox:~/Documents/ICS2021/ics2021/nemu$
```

```
# Automatically generated file; DO NOT EDIT.
# NEMU Configuration Menu
#
CONFIG_DIFFTEST_REF_NAME="none"
CONFIG_ENGINE="interpreter"
CONFIG_PC_RESET_OFFSET=0
CONFIG_TARGET_NATIVE_ELF=y
CONFIG_MSIZE=0x8000000
CONFIG_CC_O2=y
CONFIG_MODE_SYSTEM=y
CONFIG_MEM_RANDOM=y
CONFIG_ISA_riscv32=y
CONFIG_LOG_START=0
CONFIG_MBASE=0x80000000
CONFIG_TIMER_GETTIMEOFDAY=y
CONFIG_ENGINE_INTERPRETER=y
CONFIG_CC_OPT="-O2"
CONFIG_LOG_END=10000
CONFIG_RT_CHECK=y
CONFIG_CC="gcc"
CONFIG_DIFFTEST_REF_PATH="none"
CONFIG_CC_DEBUG=y
CONFIG_CC_GCC=y
CONFIG_DEBUG=y
CONFIG_ISA="riscv32"
```

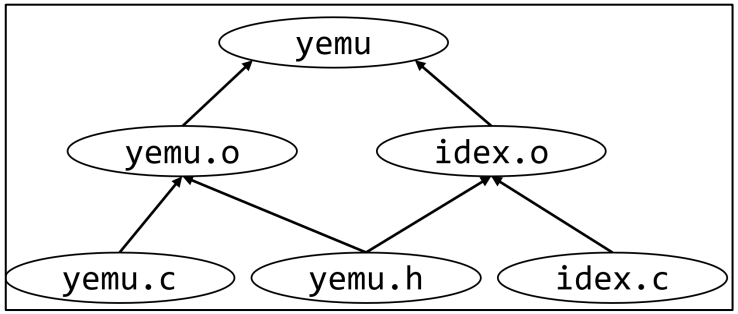
```
~/Documents/ICS2021/ics2021/nemu/include/config/auto.conf[+1]                [conf] unix utf-8 Ln 1, Col 0/26
:q
[0] 0:bash*                                                                  "why-Vi 英 简 拼 22-9月 -21
```

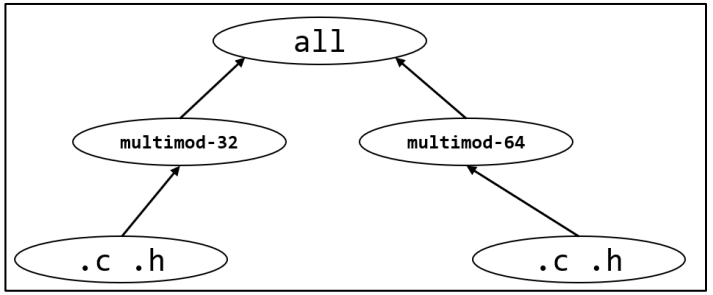
Right Shift + Right Alt

NEMU代码构建

- Makefile 真复杂
  - 放弃?

- 一个小诀窍
  - 先观察 make 命令实际执行了什么 (trace)






Applications
NEMU 框架选讲 (1): 编译…
Terminal - why@debian...
10:21
why
Terminal - why@debian: ~/ics2021/nemu
File Edit View Terminal Tabs Help
$ ls
configs include Kconfig Makefile README.md resource scripts src tools
$

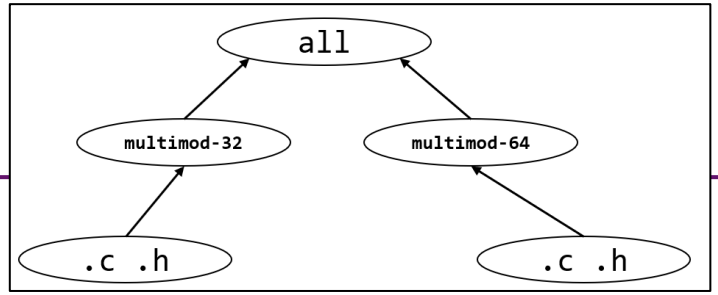
```
.DEFAULT_GOAL = app

# Add necessary options if the target is a shared library
ifdef SHARE
SO = -so
CFLAGS  += -fPIC
LDFLAGS += -rdynamic -shared -fPIC
endif

WORK_DIR  = $(shell pwd)
BUILD_DIR = $(WORK_DIR)/build

INC_PATH := $(WORK_DIR)/include $(INC_PATH)
OBJ_DIR  = $(BUILD_DIR)/obj-$(NAME)$(SO)
BINARY   = $(BUILD_DIR)/$(NAME)$(SO)

CC ?= gcc

# Compilation flags
CC := $(CC)
LD := $(CC)
INCLUDES = $(addprefix -I, $(INC_PATH))
CFLAGS  := -O2 -MMD -Wall -Werror $(INCLUDES) $(CFLAGS)
LDFLAGS := -O2 $(LDFLAGS)

OBJS = $(SRCS:%.c=$(OBJ_DIR)/%.o)

# Compilation patterns
$(OBJ_DIR)/%.o: %.c
  @echo + CC $<
  @mkdir -p $(dir $@)
  @$(CC) $(CFLAGS) -c -o $@ $<
  $(call call_fixdep, $(@:.o=.d), $@)

# Depencies
-include $(OBJS:.o=.d)

# Some convenient rules

.PHONY: app clean

app: $(BINARY)

$(BINARY): $(OBJS) $(ARCHIVES)
  @echo + LD $@
  @$(LD) -o $@ $(OBJS) $(LDFLAGS) $(ARCHIVES) $(LIBS)

clean:
  -rm -rf $(BUILD_DIR)
~/Documents/ICS2021/ics2021/nemu/scripts/build.mk[2] [make] unix utf-8 Ln 46, Col 53/49
-- INSERT --
[0] 0:vim*
```

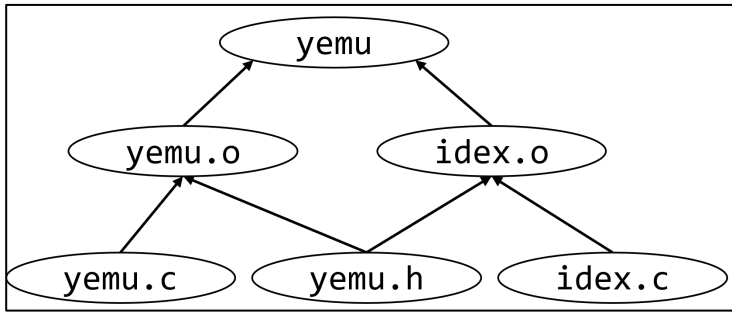
Terminal - why@debian: ~/ics2021/nemu

File Edit View Terminal Tabs Help

```
uthor='tracer-ics2021 <tracer@njuics.org>' --no-verify --allow-empty
sync
echo + LD /home/why/ics2021/nemu/build/riscv32-nemu-interpreter
gcc -o /home/why/ics2021/nemu/build/riscv32-nemu-interpreter /home/why/ics2021/nemu/bu
ild/obj-riscv32-nemu-interpreter/src/nemu-main.o /home/why/ics2021/nemu/build/obj-risc
v32-nemu-interpreter/src/engine/interpreter/init.o /home/why/ics2021/nemu/build/obj-ri
scv32-nemu-interpreter/src/engine/interpreter/hostcall.o /home/why/ics2021/nemu/build/
obj-riscv32-nemu-interpreter/src/isa/riscv32/init.o /home/why/ics2021/nemu/build/obj-r
iscv32-nemu-interpreter/src/isa/riscv32/system/intr.o /home/why/ics2021/nemu/build/obj
-riscv32-nemu-interpreter/src/isa/riscv32/system/mmu.o /home/why/ics2021/nemu/build/ob
j-riscv32-nemu-interpreter/src/isa/riscv32/instr/decode.o /home/why/ics2021/nemu/build
/obj-riscv32-nemu-interpreter/src/isa/riscv32/logo.o /home/why/ics2021/nemu/build/obj-
riscv32-nemu-interpreter/src/isa/riscv32/reg.o /home/why/ics2021/nemu/build/obj-riscv3
2-nemu-interpreter/src/isa/riscv32/difftest/dut.o /home/why/ics2021/nemu/build/obj-ris
cv32-nemu-interpreter/src/cpu/cpu-exec.o /home/why/ics2021/nemu/build/obj-riscv32-nemu
-interpreter/src/cpu/difftest/dut.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-inte
rpreter/src/monitor/monitor.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-interprete
r/src/monitor/sdb/watchpoint.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-interpret
er/src/monitor/sdb/sdb.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-interpreter/src
/monitor/sdb/expr.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-interpreter/src/util
s/log.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-interpreter/src/utils/state.o /h
ome/why/ics2021/nemu/build/obj-riscv32-nemu-interpreter/src/utils/timer.o /home/why/ic
s2021/nemu/build/obj-riscv32-nemu-interpreter/src/utils/rand.o /home/why/ics2021/nemu/
build/obj-riscv32-nemu-interpreter/src/memory/paddr.o /home/why/ics2021/nemu/build/obj
-riscv32-nemu-interpreter/src/memory/vaddr.o /home/why/ics2021/nemu/build/obj-riscv32-
nemu-interpreter/src/device/io/map.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-int
erpreter/src/device/io/mmio.o /home/why/ics2021/nemu/build/obj-riscv32-nemu-interprete
r/src/device/io/port-io.o -O2 -O2    -lreadline -ldl -pie
$
$
```

NEMU代码构建

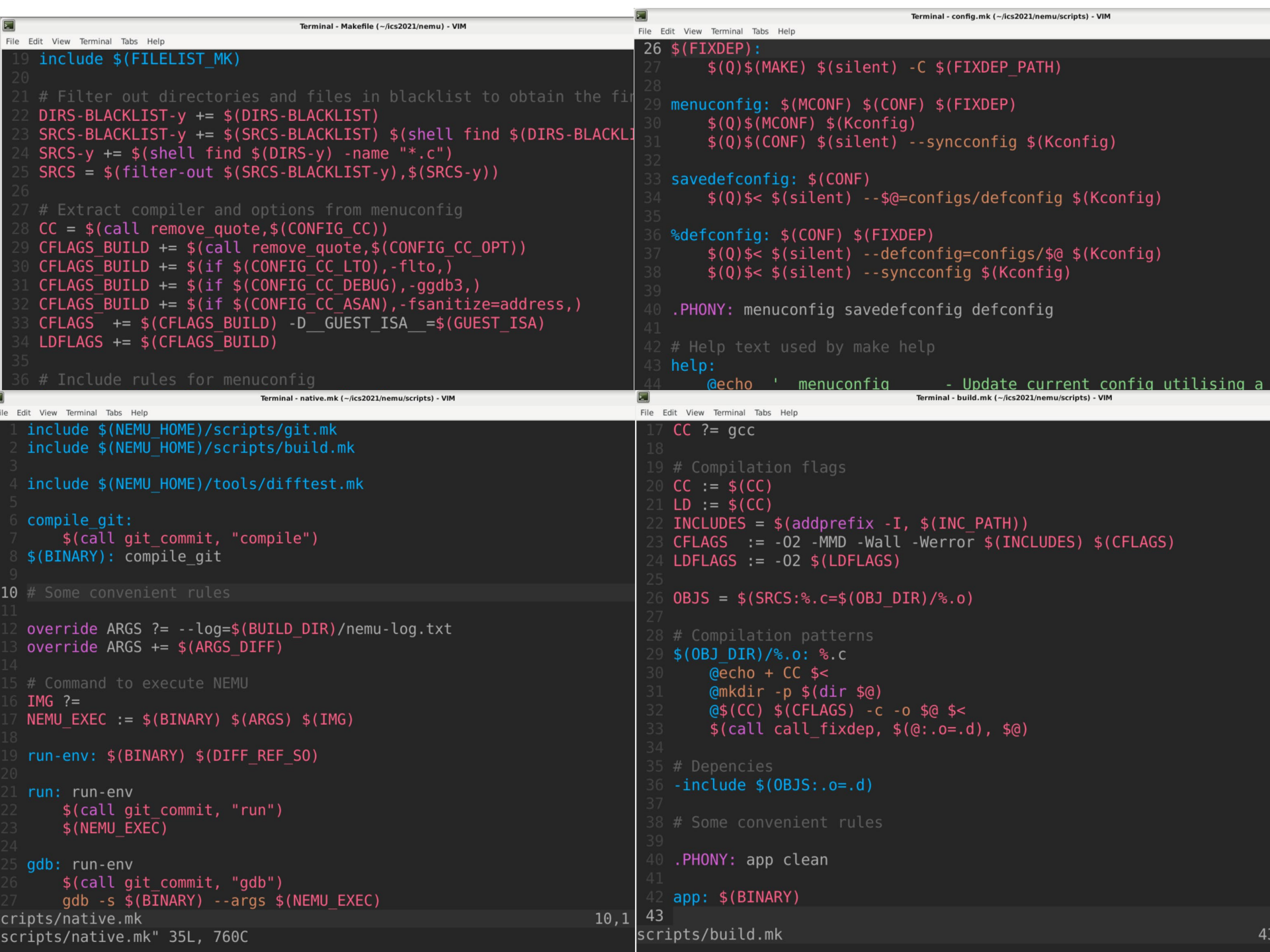




- Makefile 真复杂
  - 放弃?
- 一个小诀窍
  - 先观察 make 命令实际执行了什么 (trace)
  - RTFM/STFW: make 提供的两个有用的选项
    - `-n` 只打印命令不运行
    - `-B` 强制 make 所有目标

```
make -nB \
  | grep -ve '^\(\#\|echo\|mkdir\)' \
  | vim -
```

```
.DEFAULT_GOAL = app

# Add necessary options if the target is a shared library
ifdef SHARE
SO = -so
CFLAGS  += -fPIC
LDFLAGS += -rdynamic -shared -fPIC
endif

WORK_DIR  = $(shell pwd)
BUILD_DIR = $(WORK_DIR)/build

INC_PATH := $(WORK_DIR)/include $(INC_PATH)
OBJ_DIR  = $(BUILD_DIR)/obj-$(NAME)$(SO)
BINARY   = $(BUILD_DIR)/$(NAME)$(SO)

CC ?= gcc

# Compilation flags
CC := $(CC)
LD := $(CC)
INCLUDES = $(addprefix -I, $(INC_PATH))
CFLAGS  := -O2 -MMD -Wall -Werror $(INCLUDES) $(CFLAGS)
LDFLAGS := -O2 $(LDFLAGS)

OBJS = $(SRCS:%.c=$(OBJ_DIR)/%.o)

# Compilation patterns
$(OBJ_DIR)/%.o: %.c
  @echo + CC $<
  @mkdir -p $(dir $@)
  @$(CC) $(CFLAGS) -c -o $@ $<
  $(call call_fixdep, $(@:.o=.d), $@)

# Depencies
-include $(OBJS:.o=.d)

# Some convenient rules

.PHONY: app clean

app: $(BINARY)

$(BINARY): $(OBJS) $(ARCHIVES)
  @echo + LD $@
  @$(LD) -o $@ $(OBJS) $(LDFLAGS) $(ARCHIVES) $(LIBS)

clean:
  -rm -rf $(BUILD_DIR)
~/Documents/ICS2021/ics2021/nemu/scripts/build.mk[2] [make] unix utf-8 Ln 46, Col 53/49
-- INSERT --
[0] 0:vim*
```


Terminal - Makefile (~/ics2021/nemu) - VIM
File Edit View Terminal Tabs Help
include $(FILELIST_MK)
Filter out directories and files in blacklist to obtain the fi
DIRS-BLACKLIST-y += $(DIRS-BLACKLIST)
SRCS-BLACKLIST-y += $(SRCS-BLACKLIST) $(shell find $(DIRS-BLACKLI
SRCS-y += $(shell find $(DIRS-y) -name "*.c")
SRCS = $(filter-out $(SRCS-BLACKLIST-y),$(SRCS-y))
# Extract compiler and options from menuconfig
CC = $(call remove_quote,$(CONFIG_CC))
CFLAGS_BUILD += $(call remove_quote,$(CONFIG_CC_OPT))
CFLAGS_BUILD += $(if $(CONFIG_CC_LTO),-flto,)
CFLAGS_BUILD += $(if $(CONFIG_CC_DEBUG),-ggdb3,)
CFLAGS_BUILD += $(if $(CONFIG_CC_ASAN),-fsanitize=address,)
CFLAGS += $(CFLAGS_BUILD) -D__GUEST_ISA__=$(GUEST_ISA)
LDFLAGS += $(CFLAGS_BUILD)
Include rules for menuconfig
Terminal - config.mk (~/ics2021/nemu/scripts) - VIM
File Edit View Terminal Tabs Help
$(FIXDEP):
(Q)(MAKE) $(silent) -C $(FIXDEP_PATH)
menuconfig: $(MCONF) $(CONF) $(FIXDEP)
(Q)(MCONF) $(Kconfig)
(Q)(CONF) $(silent) --syncconfig $(Kconfig)
savedefconfig: $(CONF)
(Q)< $(silent) --$@=configs/defconfig $(Kconfig)
%defconfig: $(CONF) $(FIXDEP)
(Q)< $(silent) --defconfig=configs/$@ $(Kconfig)
(Q)< $(silent) --syncconfig $(Kconfig)
.PHONY: menuconfig savedefconfig defconfig
Help text used by make help
help:
@echo ' menuconfig   - Update current config utilising a
Terminal - native.mk (~/ics2021/nemu/scripts) - VIM
File Edit View Terminal Tabs Help
include $(NEMU_HOME)/scripts/git.mk
include $(NEMU_HOME)/scripts/build.mk
include $(NEMU_HOME)/tools/difftest.mk
compile_git:
$(call git_commit, "compile")
$(BINARY): compile_git
Some convenient rules
override ARGS ?= --log=$(BUILD_DIR)/nemu-log.txt
override ARGS += $(ARGS_DIFF)
Command to execute NEMU
IMG ?=
NEMU_EXEC := $(BINARY) $(ARGS) $(IMG)
run-env: $(BINARY) $(DIFF_REF_SO)
run: run-env
$(call git_commit, "run")
$(NEMU_EXEC)
gdb: run-env
$(call git_commit, "gdb")
gdb -s $(BINARY) --args $(NEMU_EXEC)
cripts/native.mk 10,1
scripts/native.mk" 35L, 760C
Terminal - build.mk (~/ics2021/nemu/scripts) - VIM
File Edit View Terminal Tabs Help
CC ?= gcc
Compilation flags
CC := $(CC)
LD := $(CC)
INCLUDES = $(addprefix -I, $(INC_PATH))
CFLAGS := -O2 -MMD -Wall -Werror $(INCLUDES) $(CFLAGS)
LDFLAGS := -O2 $(LDFLAGS)
OBJS = $(SRCS:%.c=$(OBJ_DIR)/%.o)
# Compilation patterns
$(OBJ_DIR)/%.o: %.c
@echo + CC $<
@mkdir -p $(dir $@)
@$(CC) $(CFLAGS) -c -o $@ $<
$(call call_fixdep, $(@:.o=.d), $@)
Depencies
-include $(OBJS:.o=.d)
Some convenient rules
.PHONY: app clean
app: $(BINARY)
scripts/build.mk

NEMU代码构建

- 一个小诀窍
  - 先观察 make 命令实际执行了什么 (trace)
  - RTFM/STFW: make 提供的两个有用的选项
    - `-n` 只打印命令不运行
    - `-B` 强制 make 所有目标

```
make -nB \
   | grep -ve '^\(\#\|echo\|mkdir\)’ \
   | vim -
```

- 其实没有那么复杂
  - 就是一堆gcc –c（编译）和一个gcc（链接）
    - 大部分Makefile都是编译选项

- Read the friendly source code!

AbstractMachine 代码构建

- 更长，更难读
  - 但我们给大家留了一个小彩蛋

```
# Makefile for AbstractMachine Kernels and Libraries

### *Get a more readable version of this Makefile* by `make html` (requires python-markdown)
html:
  cat Makefile | sed 's/^\([^#]\)/    \1/g' | markdown_py > Makefile.html
.PHONY: html

## 1. Basic Setup and Checks

### Default to create a bare-metal kernel image
ifeq ($(MAKECMDGOALS),)
  MAKECMDGOALS  = image
  .DEFAULT_GOAL = image
endif

### Override checks when `make clean/clean-all/html`
ifeq ($(findstring $(MAKECMDGOALS),clean|clean-all|html),)

### Print build info message
$(info # Building $(NAME)-$(MAKECMDGOALS) [$(ARCH)])
```

```
###*Get a more readable version of this Makefile* by
`make html` (requires python-markdown)
html:
   cat Makefile | sed 's/^\([^#]\)/ \1/g' | \
       markdown_py > Makefile.html
.PHONY: html
```

```

## 2. General Compilation Targets

### Create the destination directory (`build/$ARCH`)
WORK_DIR  = $(shell pwd)
DST_DIR   = $(WORK_DIR)/build/$(ARCH)
$(shell mkdir -p $(DST_DIR))

~/Documents/ICS2021/ics2021/abstract-machine/Makefile[1]          [make] unix utf-8 Ln 1, Col 1/160
```

管理 控制 视图 热键 设备 帮助

```
$ ls
am  build  klib  LICENSE  Makefile  README  scripts
$ vim Makefile
$
```

AbstractMachine 代码构建

- “现代” 的文档编写方式
  - “docs as code”，例子：LLVM 使用 Doxygen [自动生成文档]

LLVM 14.0.0git

Main Page | Related Pages | Modules | Namespaces | Classes | Files

Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

N adjust	
N AllocaSlices	
N false	
N INITIALIZE_PASS	TargetPassConfig
N llvm	----------—— Pc ——
N std	
C __itt_api_info	
C __itt_api_info_20101001	
C __itt_global	
C __itt_group_list	
C __itt_thread_info	
C _iJIT_Method_Id	
C _iJIT_Method_Load	
C _iJIT_Method_NIDS	
C _LineNumberInfo	
C AAAlignArgument	Align attribute for functi
C AAAlignCallSiteArgument	
C AAAlignCallSiteReturned	Align attribute deductio

LLVM 14.0.0git

Main Page | Related Pages | Modules | Namespaces | Classes | Files | Examples

llvm › AA

Namespaces | Functions

llvm::AA Namespace Reference

Abstract **Attribute** helper functions. More...

Namespaces

PointerInfo

Functions

bool **isDynamicallyUnique** (**Attributor** &A, const **AbstractAttribute** &QueryingAA, const **Value** &V)
Return true if V is dynamically unique, that is, there are no two "instances" of V at runtime with different values. More...

bool **isValidInScope** (const **Value** &V, const **Function** *Scope)
Return true if V is a valid value in Scope, that is a constant or an instruction/argument of Scope. More...

bool **isValidAtPosition** (const **Value** &V, const **Instruction** &CtxI, **InformationCache** &InfoCache)
Return true if V is a valid value at position CtxI, that is a constant, an argument of the same function as CtxI, or an instruction in that function that dominates CtxI. More...

Value * **getWithType** (**Value** &V, **Type** &Ty)
Try to convert V to type Ty without introducing new instructions. More...

Optional< **Value** * > **combineOptionalValuesInAAValueLatice** (const **Optional**< **Value** * > &A, const **Optional**< **Value** * > &B, **Type** *Ty)
Return the combination of A and B such that the result is a possible value of both. More...

Constant * **getInitialValueForObj** (**Value** &Obj, **Type** &Ty)
Return the initial value of Obj with type Ty if that is a constant. More...

bool **getAssumedUnderlyingObjects** (**Attributor** &A, const **Value** &Ptr, **SmallVectorImpl**< **Value** * > &Objects, const **AbstractAttribute** &QueryingAA, const **Instruction** *CtxI)
Collect all potential underlying objects of Ptr at position CtxI in Objects. More...

bool **getPotentialCopiesOfStoredValue** (**Attributor** &A, **StoreInst** &SI, **SmallSetVector**< **Value** *, 4 > &PotentialCopies, const **AbstractAttribute** &QueryingAA, bool &UsedAssumedInformation)
Collect all potential values of the one stored by SI into PotentialCopies. More...

Detailed Description

Abstract **Attribute** helper functions.

Function Documentation

combineOptionalValuesInAAValueLatice()

Optional< **Value** * > llvm::AA::combineOptionalValuesInAAValueLatice (const **Optional**< **Value** * > & A,
const **Optional**< **Value** * > & B,
Type * Ty
)

Return the combination of A and B such that the result is a possible value of both.

B is potentially casted to match the type Ty or the type of A if Ty is null.

pydoc

- `pydoc3 list`

```
Help on class list in module builtins:

class list(object)
 |  list(iterable=(), /)
 |
 |  Built-in mutable sequence.
 |
 |  If no argument is given, the constructor creates a new empty list.
 |  The argument must be an iterable if specified.
 |
 |  Methods defined here:
 |
 |  __add__(self, value, /)
 |      Return self+value.
 |
 |  __contains__(self, key, /)
 |      Return key in self.
 |
 |  __delitem__(self, key, /)
 |      Delete self[key].
 |
 |  __eq__(self, value, /)
 |      Return self==value.
 |
 |  __ge__(self, value, /)
 |      Return self>=value.
 |
 |  __getattribute__(self, name, /)
 |      Return getattr(self, name).
 |
 |  __getitem__(...)
 |      x.__getitem__(y) <==> x[y]
 |
 |  __gt__(self, value, /)
 |      Return self>value.
 |
 |  __iadd__(self, value, /)
 |      Implement self+=value.
 |
 |  __imul__(self, value, /)
 |      Implement self*=value.
 |
 |  __init__(self, /, *args, **kwargs)
 |      Initialize self.  See help(type(self)) for accurate signature.
 |
 |  __iter__(self, /)
 |      Implement iter(self).
 |
 |  __le__(self, value, /)
 |      Return self<=value.
:
```

总结

关于《计算机系统基础》习题课

- 教会大家 “计算机的正确打开方式”
  - 编程 ≠ 闷头写代码
  - 使用工具也是编程的一部分
    - version-control systems: git, svn, ...
    - build systems: make, cmake (C++), maven (Java), ...
    - shell: bash, zsh, ...

- 基本原则：任何感到不爽的事情都一定有工具能帮你
  - 如果真的没有，自己造一个的就会就来了
    - (不太可能是真的)
    - 但这将会是一份非常好的研究工作

End.

(RTFM & RTFSC)