浙江大学实验报告

课程名称：操作系统
实验项目名称：Rinux环境搭建和内核编译
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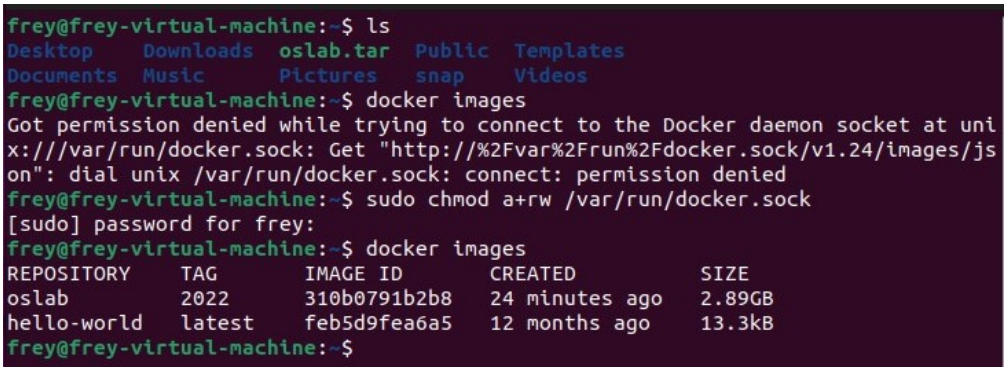
实验日期： 2022年 9 月 26 日

一、实验内容

1. 搭建Docker环境

- 导入docker镜像




```shell
cat oslab.tar | docker import - oslab:2022
#使用cat命令加管道 使oslab.tar作为docker import的输入导入，命名为
  #oslab: 2022
docker images
#导入docker镜像后查看docker镜像
chmod a+rw ...
#给所有用户对docker.sock文件添加读写权限
```

- 创建容器

```
frey@frey-virtual-machine:~$ docker run --name oslab -it oslab:2022 /bin/bash
root@c6f46b640a42:/# id
uid=0(root) gid=0(root) groups=0(root)
root@c6f46b640a42:/# exit
exit
```

SHELL

```
docker run --name oslab -it oslab:2022 /bin/bash
# --name 指定容器名为oslab -it交互式操作，运行在终端/bin/bash
```

2. 获取Linux源码和已经编译好的文件系统

- 克隆lab0仓库

```
root@c6f46b640a42:/home# git clone https://gitee.com/zjusec/os21fall
Cloning into 'os21fall'...
fatal: unable to access 'https://gitee.com/zjusec/os21fall/': Could not resolve host: gitee.com
root@c6f46b640a42:/home#
```

遇见问题： docker内git clone命令无法解析地址

解决： 在docker外克隆后复制到容器内

```
frey@frey-virtual-machine:~$ git clone https://gitee.com/zjusec/os21fall
Cloning into 'os21fall'...
Username for 'https://gitee.com': 1
Password for 'https://1@gitee.com':
remote: [session-114c5793] 1: Incorrect username or password (access token)
fatal: Authentication failed for 'https://gitee.com/zjusec/os21fall/'
frey@frey-virtual-machine:~$  git clone  https://gitee.com/ilfth/os21fall
Cloning into 'os21fall'...
remote: Enumerating objects: 10, done.
remote: Counting objects: 100% (10/10), done.
remote: Compressing objects: 100% (8/8), done.
remote: Total 10 (delta 0), reused 0 (delta 0), pack-reused 0
Receiving objects: 100% (10/10), 1.09 MiB | 419.00 KiB/s, done.
frey@frey-virtual-machine:~$ ls
Desktop    Downloads  os21fall   Pictures  snap       Videos
Documents  Music      oslab.tar  Public    Templates
frey@frey-virtual-machine:~$ docker ps
CONTAINER ID   IMAGE         COMMAND       CREATED       STATUS       PORTS     NAMES
c6f46b640a42   oslab:2022    "/bin/bash"   13 days ago   Up 13 days             oslab
frey@frey-virtual-machine:~$ docker cp /home/os21fall c6f46b640a42:home
lstat /home/os21fall: no such file or directory
frey@frey-virtual-machine:~$ docker cp ./os21fall c6f46b640a42:home
frey@frey-virtual-machine:~$ docker exec -it oslab /bin/bash
root@c6f46b640a42:/# ls
bin   dev  home     lib    libexec  mnt  proc  run   share  sys  usr
boot  etc  include  lib64  media    opt  root  sbin  srv    tmp  var
root@c6f46b640a42:/# cd home
root@c6f46b640a42:/home# ls
os21fall  oslab
root@c6f46b640a42:/home# cd os21fall
root@c6f46b640a42:/home/os21fall# cd src/lab0
root@c6f46b640a42:/home/os21fall/src/lab0# ls
rootfs.img
```

```shell
docker ps
#显示所有在运行的容器
docker cp 源地址 目标容器：目标地址
#将文件从docker外拷贝到容器内
```

- 安装wget工具

```
root@c6f46b640a42:/home/os21fall/src/lab0# apt install wget
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  wget
0 upgraded, 1 newly installed, 0 to remove and 22 not upgraded.
Need to get 316 kB of archives.
After this operation, 954 kB of additional disk space will be used.
Ign:1 http://mirrors.aliyun.com/ubuntu bionic-security/main amd64 wget amd64 1.19.4-1ubuntu2.2
Err:1 http://mirrors.aliyun.com/ubuntu bionic-security/main amd64 wget amd64 1.19.4-1ubuntu2.2
  Temporary failure resolving 'mirrors.aliyun.com'
E: Failed to fetch http://mirrors.aliyun.com/ubuntu/pool/main/w/wget/wget_1.19.4-1ubuntu2.2_amd64.deb
  Temporary failure resolving 'mirrors.aliyun.com'
E: Unable to fetch some archives, maybe run apt-get update or try with --fix-missing?
root@c6f46b640a42:/home/os21fall/src/lab0#
```

遇见问题：docker容器内无法联网

解决：docker rm删除当前容器，新建容器加入 --net host 与宿主机共享网络配置

```
frey@frey-virtual-machine:~$ docker run --name oslab --net host -it oslab:2022 /bin/bash
root@frey-virtual-machine:/# cd /home
root@frey-virtual-machine:/home# ls
oslab
root@frey-virtual-machine:/home# git clone https://gitee.com/ilfth/os21fall
Cloning into 'os21fall'...
remote: Enumerating objects: 10, done.
remote: Counting objects: 100% (10/10), done.
remote: Compressing objects: 100% (8/8), done.
remote: Total 10 (delta 0), reused 0 (delta 0), pack-reused 0
Unpacking objects: 100% (10/10), done.
root@frey-virtual-machine:/home#
```

- 下载linux源码并解压

```
linux-5.19.8/virt/kvm/pfncache.c
linux-5.19.8/virt/kvm/vfio.c
linux-5.19.8/virt/kvm/vfio.h
linux-5.19.8/virt/lib/
linux-5.19.8/virt/lib/Kconfig
linux-5.19.8/virt/lib/Makefile
linux-5.19.8/virt/lib/irqbypass.c
root@frey-virtual-machine:/home/os21fall/src/lab0# ls
linux-5.19.8  linux-5.19.8.tar.gz  rootfs.img
root@frey-virtual-machine:/home/os21fall/src/lab0#
```

```shell
tar -zxvf filename
#tar：用于建立，还原，加入，解开备份（打包）文件
#-z 通过gzip压缩或解压 -x 从备份文件还原文件
#-v 显示详细过程 -f 指定备份文件
```

3. **编译Linux内核**

- 配置环境变量

```
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# export RISCV=/opt/riscv
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# export PATH=$PATH:$RISCV/bin
```

```shell
export RISCV=/opt/riscv
#export 设置环境变量 RISCV 仅在当前终端和当前用户生效
export PATH=$PATH:$RISCV/bin
#将$RISCV/bin添加到PATH中
```

- 生成配置

```
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# make ARCH=riscv defconfig
*** Default configuration is based on 'defconfig'
#
# configuration written to .config
#
```

指定内核编译配置为RISC-V平台的默认配置

- 开始编译内核

```
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# make ARCH=riscv
CROSS_COMPILE=riscv64-unknown-linux-gnu- -j4
  SYNC    include/config/auto.conf.cmd
*
* Restart config...
*
*
* GCC plugins
*
GCC plugins (GCC_PLUGINS) [Y/n/?] (NEW) y
  Generate some entropy during boot and runtime (GCC_PLUGIN_LATENT_ENTROPY) [N/y
/?] (NEW) n
*
* Memory initialization
*
Initialize kernel stack variables at function entry
> 1. no automatic stack variable initialization (weakest) (INIT_STACK_NONE)
  2. zero-init structs marked for userspace (weak) (GCC_PLUGIN_STRUCTLEAK_USER)
(NEW)
  3. zero-init structs passed by reference (strong) (GCC_PLUGIN_STRUCTLEAK_BYREF
) (NEW)
  4. zero-init everything passed by reference (very strong) (GCC_PLUGIN_STRUCTLE
AK_BYREF_ALL) (NEW)
choice[1-4?]: 1
```

```
Initialize kernel stack variables at function entry
> 1. no automatic stack variable initialization (weakest) (INIT_STACK_NONE)
  2. zero-init structs marked for userspace (weak) (GCC_PLUGIN_STRUCTLEAK_USER)
(NEW)
  3. zero-init structs passed by reference (strong) (GCC_PLUGIN_STRUCTLEAK_BYREF
) (NEW)
  4. zero-init everything passed by reference (very strong) (GCC_PLUGIN_STRUCTLE
AK_BYREF_ALL) (NEW)
choice[1-4?]: 1
Enable heap memory zeroing on allocation by default (INIT_ON_ALLOC_DEFAULT_ON) [
N/y/?] n
Enable heap memory zeroing on free by default (INIT_ON_FREE_DEFAULT_ON) [N/y/?]
n
*
* Kernel hardening options
*
Randomize layout of sensitive kernel structures
> 1. Disable structure layout randomization (RANDSTRUCT_NONE)
  2. Fully randomize structure layout (RANDSTRUCT_FULL) (NEW)
  3. Limit randomization of structure layout to cache-lines (RANDSTRUCT_PERFORMA
NCE) (NEW)
choice[1-3?]: 1
```

指定交叉编译工具链，进行多线程编程，线程数为4

4. **使用QEMU运行内核**

```
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# qemu-system-risc
v64 -nographic -machine virt -kernel ./arch/riscv/boot/Image -device virtio-blk-
device,drive=hd0 -append "root=/dev/vda ro console=ttyS0" -bios default -drive f
ile=../rootfs.img,format=raw,id=hd0
```

```shell
        qemu-system-riscv64 #使用qemu完成riscv64架构的模拟
        -nographic #不使用图形化窗口
        -machine virt #指定要模拟的机器为RISCV VirtIO board
        -kernel #指定对应架构的内核镜像
        -device #指定要模拟的设备 virtio-blk-device指定的为
storage device
        #即存储设备 相应的总线bus为virtio-bus hd0:第一个硬盘
        -append cmdline #使用cmdline作为内核的命令行
        -bios default #使用默认的 OpenSBI firmware 作为
bootloader
        #ttyS0 串行端口终端
        -drive #指定文件系统
```

5. **使用gdb对内核进行调试**

- 使用QEMU启动linux内核

```
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# qemu-system-risc
v64 -nographic -machine virt -kernel ./arch/riscv/boot/Image -device virtio-blk-
device,drive=hd0 -append "root=/dev/vda ro console=ttyS0" -bios default -drive f
ile=../rootfs.img,format=raw,id=hd0 -S -s
```

```shell
        -S #启动时暂停cpu执行
        -s #-gdb tcp::1234 的简写，使用gdb调试，可用tcp 1234端
口连接
```

- 打开另一个Terminal Session，连接docker使用gdb连接QEMU

```
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# riscv64-unknown-
linux-gnu-gdb ./vmlinux
GNU gdb (GDB) 9.1
Copyright (C) 2020 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "--host=x86_64-pc-linux-gnu --target=riscv64-unknown-
linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
    <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./vmlinux...
(No debugging symbols found in ./vmlinux)
(gdb)
```

此处显示(No debugging symbols found)，则需重新编译内核

- 修改内核MAKEFILE

```
KBUILD_AFLAGS   := -D__ASSEMBLY__ -fno-PIE
KBUILD_CFLAGS   := -Wall -Wundef -Werror=strict-prototypes -Wno-trigraphs \
                   -fno-strict-aliasing -fno-common -fshort-wchar -fno-PIE \
                   -Werror=implicit-function-declaration -Werror=implicit-int \
                   -Werror=return-type -Wno-format-security \
                   -std=gnu11 -g
```

- 重新编译内核

```
root@frey-virtual-machine:/home/os21fall/src/lab0/linux-5.19.8# make ARCH=riscv
CROSS_COMPILE=riscv64-unknown-linux-gnu- -j4
  CC      scripts/mod/empty.o
  CC      scripts/mod/devicetable-offsets.s
  MKELF   scripts/mod/elfconfig.h
  HOSTCC  scripts/mod/modpost.o
  HOSTCC  scripts/mod/sumversion.o
  HOSTCC  scripts/mod/file2alias.o
  HOSTLD  scripts/mod/modpost
```

三、讨论心得

1. 在docker内使用git clone失败
   原本认为是gitee连接有问题，遂在docker容器外下载文件系统并拷贝入容器，但在后续实验过程中使用wget，apt等工具时均无法连接到网络，经过查询重新建立容器并加入-net host选项使docker容器与宿主机共享网络配置，解决了容器的联网问题。