# EI313 Lab2

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## 1 Download QEMU and compile.

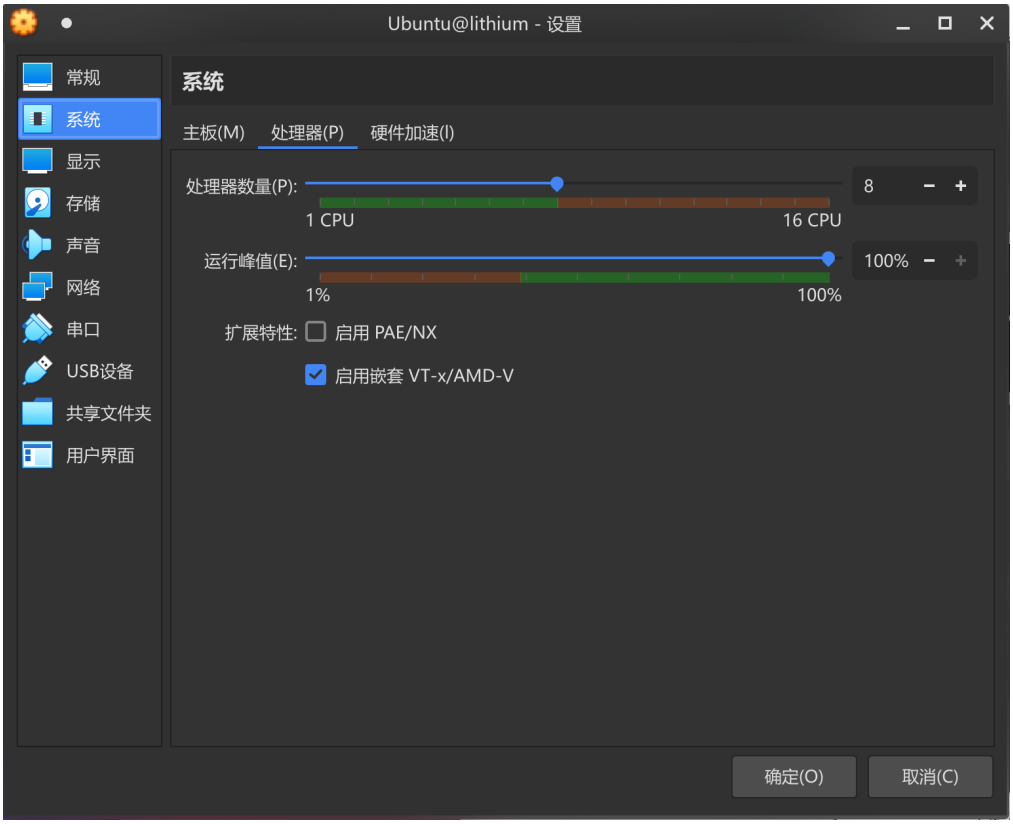
宿主机为VirtualBox中的Ubuntu 20.04 LTS，具体设备信息如下：


### 1.1 首先设置硬件支持虚拟化[1]

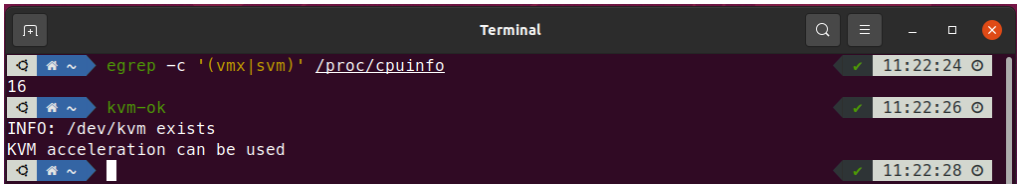
首先打开VirtualBox的嵌套虚拟化。在宿主机中输入

```
vboxmanage modifyvm "Ubuntu@lithium" --nested-hw-virt on
```

可以看到嵌套VT-x/AMD-V已打开。




然后在VirtualBox虚拟机中测试




输出结果说明虚拟机的CPU支持虚拟化。

## 1.2 下载并编译安装QEMU 5.2.0

1. 首先安装各种依赖库。[2]

```
sudo apt-get install git libglib2.0-dev libfdt-dev libpixman-1-dev zlib1g-dev
sudo apt-get install git-email
sudo apt-get install libaio-dev libbluetooth-dev libbrlapi-dev libbz2-dev
sudo apt-get install libcap-dev libcap-ng-dev libcurl4-gnutls-dev libgtk-3-dev
sudo apt-get install libibverbs-dev libjpeg8-dev libncurses5-dev libnuma-dev
sudo apt-get install librbd-dev librdmacm-dev
sudo apt-get install libsasl2-dev libsdl1.2-dev libseccomp-dev libsnappy-dev libssh2-1-dev
sudo apt-get install libvde-dev libvdeplug-dev libvte-2.90-dev libxen-dev liblzo2-dev
sudo apt-get install valgrind xfslibs-dev
sudo apt-get install libnfs-dev libiscsi-dev
```

2. 然后直接从官网下载源码并解压。

```
wget https://download.qemu.org/qemu-5.2.0.tar.xz
tar xvJf qemu-5.2.0.tar.xz
```

3. 配置并编译。注意参数`--target-list=x86_64-softmmu`，代表编译目标为x86_64架构CPU的QEMU，这样可以减少编译所需时间。[3]

```
cd qemu-5.2.0
./configure --enable-kvm --target-list=x86_64-softmmu --enable-debug
make -j8
```

开始编译：

```
Terminal
                parallels support: YES
                 sheepdog support: NO
                         capstone: internal
                  libpmem support: NO
                libdaxctl support: NO
                          libudev: NO
                  default devices: YES
                   plugin support: NO
                  fuzzing support: NO
                              gdb: /usr/bin/gdb
                 thread sanitizer: NO
                         rng-none: NO
                    Linux keyring: YES

Found ninja-1.10.0 at /usr/bin/ninja
~/To/qemu-5.2.0 make -j8                                    ✓ 8s 11:23:33
changing dir to build for make ""...
make[1]: Entering directory '/home/adswt518/Tools/qemu-5.2.0/build'
/usr/bin/ninja  build.ninja && touch build.ninja.stamp
ninja: no work to do.
/usr/bin/python3 -B /home/adswt518/Tools/qemu-5.2.0/meson/meson.py introspect --targets --tests --be
nchmarks | /usr/bin/python3 -B scripts/mtest2make.py > Makefile.mtest
  AS      multiboot.o
  AS      linuxboot.o
  CC      linuxboot_dma.o
  AS      kvmvapic.o
  AS      pvh.o
  CC      pvh_main.o
  BUILD   multiboot.img
  BUILD   linuxboot.img
```

编译完成：

```
Terminal
[2320/2342] Compiling C object tests/qtest/qos-test.p/pci-test.c.o
[2321/2342] Compiling C object tests/qtest/qos-test.p/ds1338-test.c.o
[2322/2342] Compiling C object tests/qtest/qos-test.p/sdhci-test.c.o
[2323/2342] Compiling C object tests/qtest/qos-test.p/virtio-test.c.o
[2324/2342] Compiling C object tests/qtest/qos-test.p/virtio-net-test.c.o
[2325/2342] Compiling C object tests/qtest/qos-test.p/eepro100-test.c.o
[2326/2342] Compiling C object tests/qtest/qos-test.p/virtio-9p-test.c.o
[2327/2342] Compiling C object tests/qtest/qos-test.p/pcnet-test.c.o
[2328/2342] Compiling C object tests/qtest/qos-test.p/tulip-test.c.o
[2329/2342] Compiling C object tests/qtest/qos-test.p/es1370-test.c.o
[2330/2342] Compiling C object tests/qtest/qos-test.p/virtio-scsi-test.c.o
[2331/2342] Compiling C object tests/qtest/qos-test.p/virtio-rng-test.c.o
[2332/2342] Compiling C object tests/qtest/qos-test.p/vmxnet3-test.c.o
[2333/2342] Compiling C object tests/qtest/qos-test.p/usb-hcd-ohci-test.c.o
[2334/2342] Compiling C object tests/qtest/qos-test.p/e1000e-test.c.o
[2335/2342] Compiling C object tests/qtest/qos-test.p/virtio-blk-test.c.o
[2336/2342] Compiling C object tests/qtest/qos-test.p/e1000-test.c.o
[2337/2342] Compiling C object tests/qtest/qos-test.p/pca9552-test.c.o
[2338/2342] Compiling C object tests/qtest/qos-test.p/nvme-test.c.o
[2339/2342] Compiling C object tests/qtest/qos-test.p/megasas-test.c.o
[2340/2342] Compiling C object tests/qtest/qos-test.p/vhost-user-test.c.o
[2341/2342] Compiling C object tests/qtest/qos-test.p/tmp105-test.c.o
[2342/2342] Linking target tests/qtest/qos-test
make[1]: Leaving directory '/home/adswt518/Tools/qemu-5.2.0/build'
changing dir to build for make ""...
make[1]: Entering directory '/home/adswt518/Tools/qemu-5.2.0/build'
[1/49] Generating QAPI test (include) with a custom command
[2/18] Generating qemu-version.h with a meson_exe.py custom command
make[1]: Leaving directory '/home/adswt518/Tools/qemu-5.2.0/build'
~/To/qemu-5.2.0                                             ✓ 1m 20s 11:24:55
```

然后安装：

```
~/Tools/qemu-5.2.0 sudo make install                        ✓ 18:02:55
changing dir to build for make "install"...
make[1]: Entering directory '/home/adswt518/Tools/qemu-5.2.0/build'
[1/18] Generating qemu-version.h with a meson_exe.py custom command
[1/2] Installing files.
Installing subdir /home/adswt518/Tools/qemu-5.2.0/qga/run to /usr/local/var/run
Installing trace/trace-events-all to /usr/local/share/qemu
Installing fsdev/virtfs-proxy-helper to /usr/local/libexec
Installing qemu-system-x86_64 to /usr/local/bin
Installing qga/qemu-ga to /usr/local/bin
Installing qemu-keymap to /usr/local/bin
Installing qemu-img to /usr/local/bin
Installing qemu-io to /usr/local/bin
Installing qemu-nbd to /usr/local/bin
Installing storage-daemon/qemu-storage-daemon to /usr/local/bin
Installing contrib/elf2dmp/elf2dmp to /usr/local/bin
Installing qemu-edid to /usr/local/bin
Installing qemu-bridge-helper to /usr/local/libexec
```

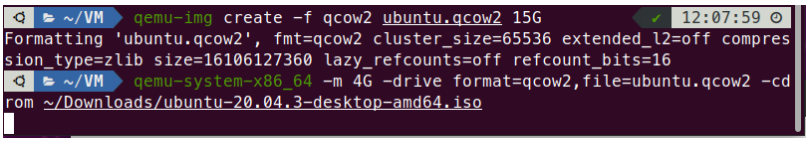
检测QEMU版本：

```
~/To/qemu-5.2.0/build ./qemu-img -V                         ✓ 11:29:09
qemu-img version 5.2.0
Copyright (c) 2003-2020 Fabrice Bellard and the QEMU Project developers
~/To/qemu-5.2.0/build                                       ✓ 11:29:45
```

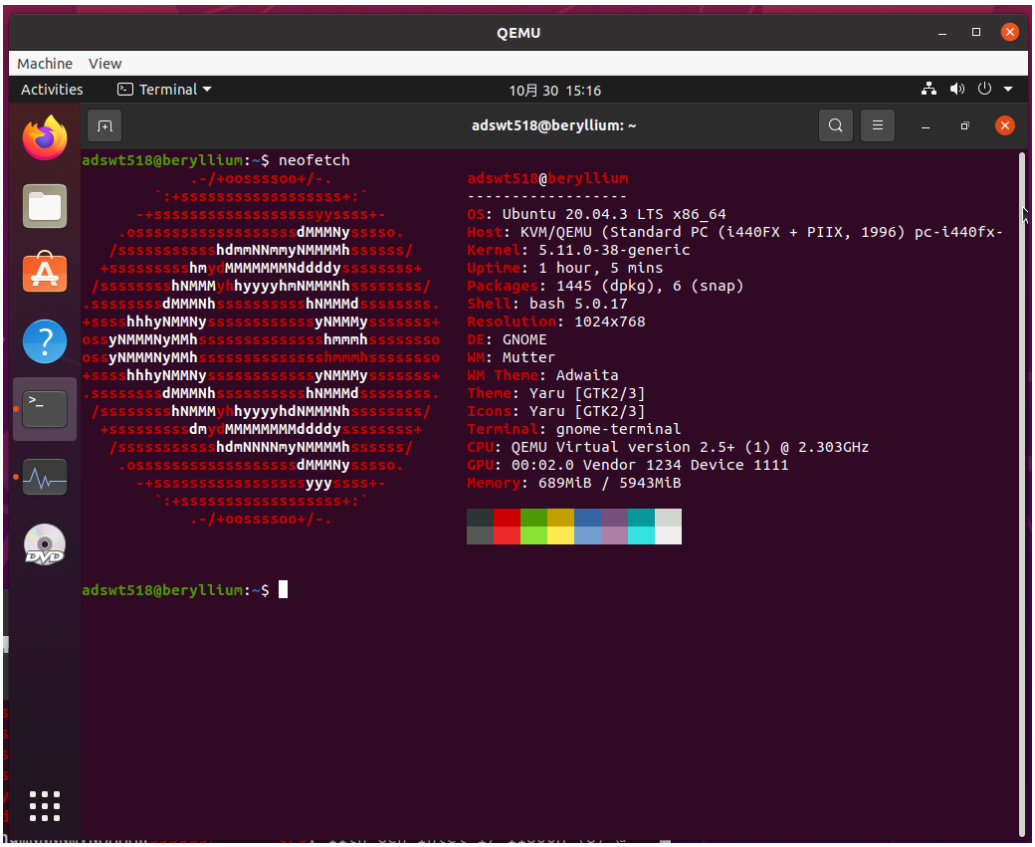
# 2 Create 2 VMs with TAP mode network (e1000 and virtio-net) by QEMU.

## 2.1 创建并安装QEMU虚拟机[3]

这里我同样选择Ubuntu 20.04 LTS作为QEMU虚拟机的系统。




安装完毕，系统信息如图所示。




## 2.2 设置QEMU虚拟机的网络

### 2.2.1 NAT配置[4]

首先安装必要的库

```
sudo apt install bridge-utils iptables dnsmasq
```

然后在`/usr/local/etc`下创建文件`qemu-ifup`，内容如下

```
#!/bin/sh
#
# Copyright IBM, Corp. 2010
#
# Authors:
#  Anthony Liguori <aliguori@us.ibm.com>
#
```

```
# This work is licensed under the terms of the GNU GPL, version 2.  See
# the COPYING file in the top-level directory.

# Set to the name of your bridge
BRIDGE=br0

# Network information
NETWORK=192.168.53.0
NETMASK=255.255.255.0
GATEWAY=192.168.53.1
DHCPRANGE=192.168.53.2,192.168.53.254

# Optionally parameters to enable PXE support
TFTPROOT=
BOOTP=

do_brctl() {
    brctl "$@"
}

do_ifconfig() {
    ifconfig "$@"
}

do_dd() {
    dd "$@"
}

do_iptables_restore() {
    iptables-restore "$@"
}

do_dnsmasq() {
    dnsmasq "$@"
}

check_bridge() {
    if do_brctl show | grep "^$1" > /dev/null 2> /dev/null; then
    return 1
    else
    return 0
    fi
}

create_bridge() {
    do_brctl addbr "$1"
    do_brctl stp "$1" off
    do_brctl setfd "$1" 0
```

```
    do_ifconfig "$1" "$GATEWAY" netmask "$NETMASK" up
}

enable_ip_forward() {
    echo 1 | do_dd of=/proc/sys/net/ipv4/ip_forward > /dev/null
}

add_filter_rules() {
do_iptables_restore <<EOF
# Generated by iptables-save v1.3.6 on Fri Aug 24 15:20:25 2007
*nat
:PREROUTING ACCEPT [61:9671]
:POSTROUTING ACCEPT [121:7499]
:OUTPUT ACCEPT [132:8691]
-A POSTROUTING -s $NETWORK/$NETMASK -j MASQUERADE
COMMIT
# Completed on Fri Aug 24 15:20:25 2007
# Generated by iptables-save v1.3.6 on Fri Aug 24 15:20:25 2007
*filter
:INPUT ACCEPT [1453:976046]
:FORWARD ACCEPT [0:0]
:OUTPUT ACCEPT [1605:194911]
-A INPUT -i $BRIDGE -p tcp -m tcp --dport 67 -j ACCEPT
-A INPUT -i $BRIDGE -p udp -m udp --dport 67 -j ACCEPT
-A INPUT -i $BRIDGE -p tcp -m tcp --dport 53 -j ACCEPT
-A INPUT -i $BRIDGE -p udp -m udp --dport 53 -j ACCEPT
-A FORWARD -i $1 -o $1 -j ACCEPT
-A FORWARD -s $NETWORK/$NETMASK -i $BRIDGE -j ACCEPT
-A FORWARD -d $NETWORK/$NETMASK -o $BRIDGE -m state --state RELATED,ESTABLISHED -j ACCEPT
-A FORWARD -o $BRIDGE -j REJECT --reject-with icmp-port-unreachable
-A FORWARD -i $BRIDGE -j REJECT --reject-with icmp-port-unreachable
COMMIT
# Completed on Fri Aug 24 15:20:25 2007
EOF
}

start_dnsmasq() {
    do_dnsmasq \
    --strict-order \
    --except-interface=lo \
    --interface=$BRIDGE \
    --listen-address=$GATEWAY \
    --bind-interfaces \
    --dhcp-range=$DHCPRANGE \
    --conf-file="" \
    --pid-file=/var/run/qemu-dnsmasq-$BRIDGE.pid \
    --dhcp-leasefile=/var/run/qemu-dnsmasq-$BRIDGE.leases \
    --dhcp-no-override \
```

```
    ${TFTPROOT:+"--enable-tftp"} \
    ${TFTPROOT:+"--tftp-root=$TFTPROOT"} \
    ${BOOTP:+"--dhcp-boot=$BOOTP"}
}

setup_bridge_nat() {
    if check_bridge "$1" ; then
    create_bridge "$1"
    enable_ip_forward
    add_filter_rules "$1"
    start_dnsmasq "$1"
    fi
}

setup_bridge_vlan() {
    if check_bridge "$1" ; then
    create_bridge "$1"
    start_dnsmasq "$1"
    fi
}

setup_bridge_nat "$BRIDGE"

if test "$1" ; then
    do_ifconfig "$1" 0.0.0.0 up
    do_brctl addif "$BRIDGE" "$1"
fi
```

并设置其权限

```
sudo chmod 755 /usr/local/etc/qemu-ifup
```

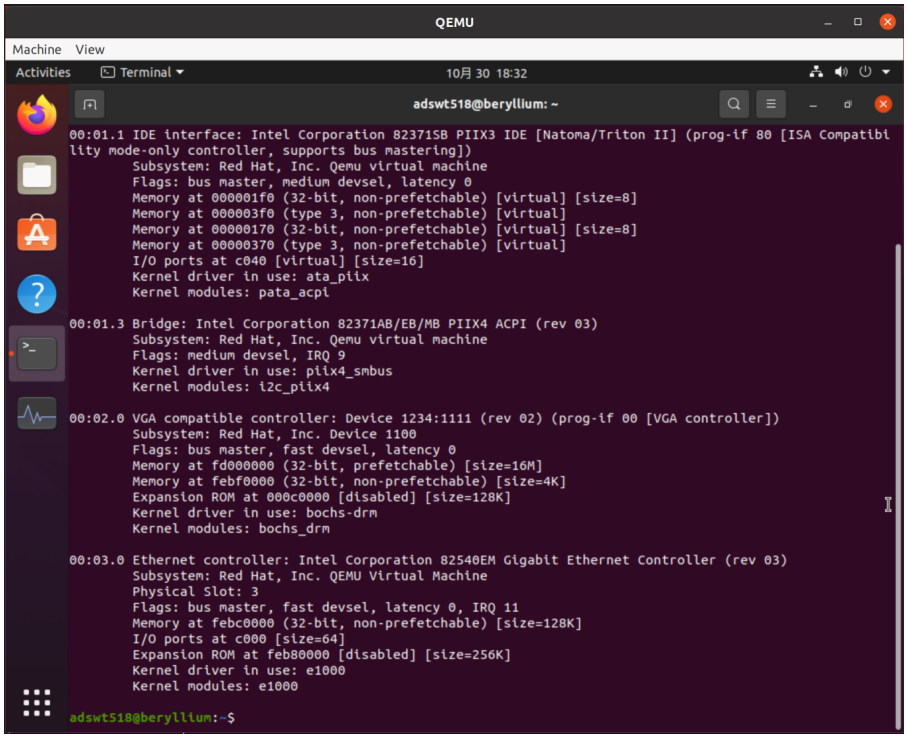
### 2.2.2 配置QEMU虚拟机网络

1. VM with TAP mode network e1000

   启动QEMU虚拟机：

   ```
   sudo qemu-system-x86_64 -m 4G -drive format=qcow2,file=ubuntu.qcow2 -enable-kvm -net nic,model=e1000 -net tap
   ```

   在虚拟机中查看其网卡信息：



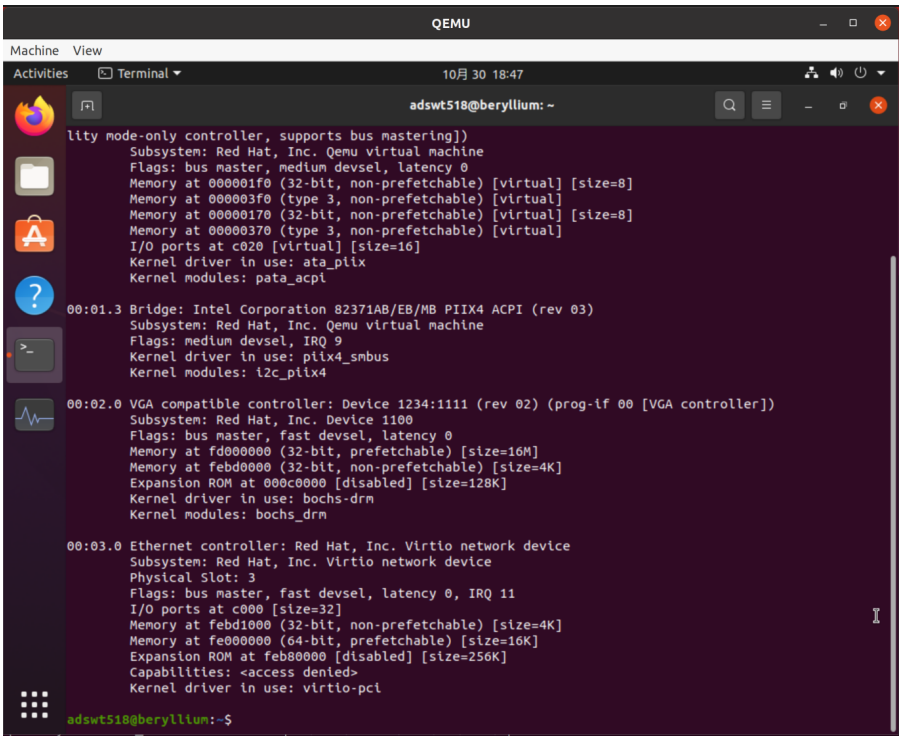

可以看到`Kernel driver in use: e1000`，`Kernel modules: e1000`，说明虚拟机使用e1000网卡。

2. VM with TAP mode network virtio-net

启动QEMU虚拟机：

```
sudo qemu-system-x86_64 -m 4G -drive format=qcow2,file=ubuntu.qcow2 -enable-kvm -net nic,model=virtio-net-pci -net tap
```

在虚拟机中查看其网卡信息：




可以看到`Kernel driver in use: virtio-pci`，说明虚拟机使用virtio驱动。

## 3 Connect to your VM through VNC viewer or SSH.

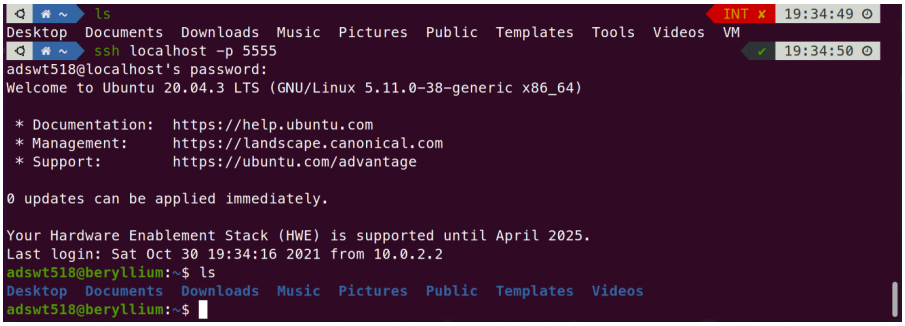
这里我使用SSH链接QEMU虚拟机。首先启动QEMU虚拟机，并设定端口。[5]

```
sudo qemu-system-x86_64 -m 4G -drive format=qcow2,file=ubuntu.qcow2 -enable-kvm -net nic -net tap -device e1000,netdev=net0 -netdev user,id=net0,hostfwd=tcp::5555-:22
```

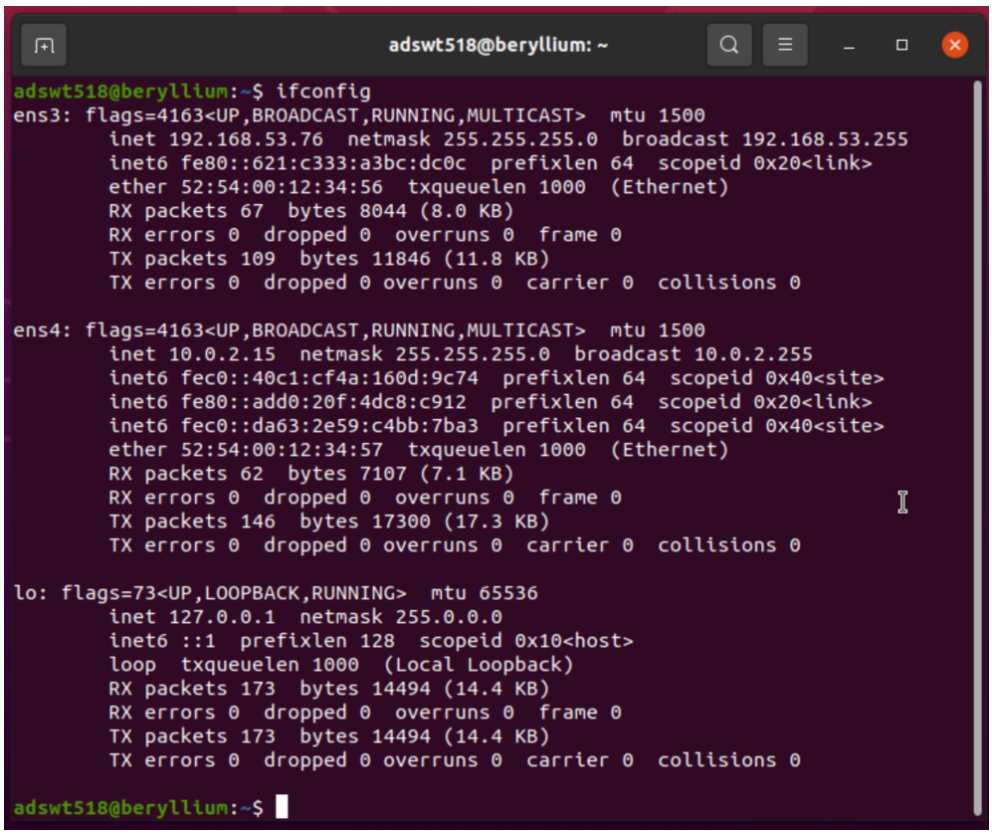
然后在VirtualBox虚拟机（相对于QEMU虚拟机来说是宿主机）的终端中输入

```
ssh localhost -p 5555
```

就可以建立宿主机与QEMU虚拟机之间的SSH连接，如图所示。



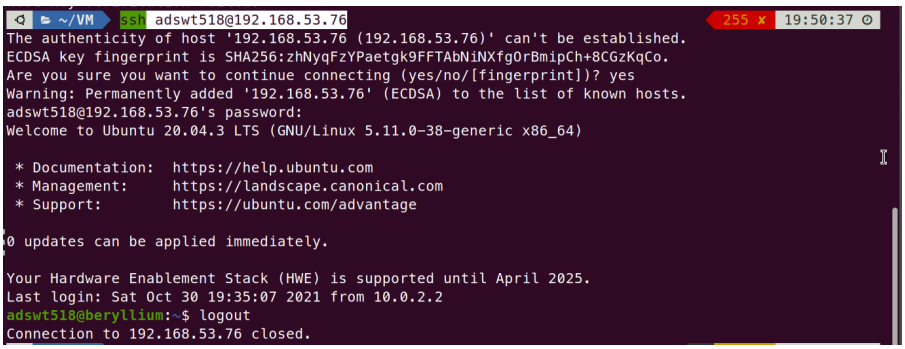

当然也可以获取QEMU虚拟机的IP地址来进行连接。使用`ifconfig`得到QEMU虚拟机网卡IP地址为`192.168.53.76`。




然后在宿主机中

```
ssh adswt518@192.168.53.76
```

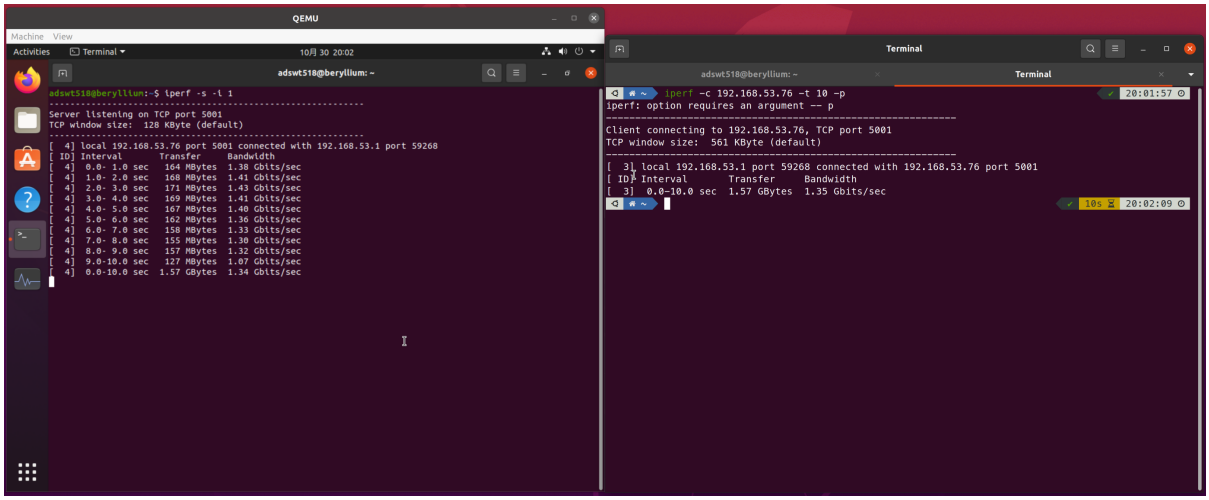
就可以连接上了。



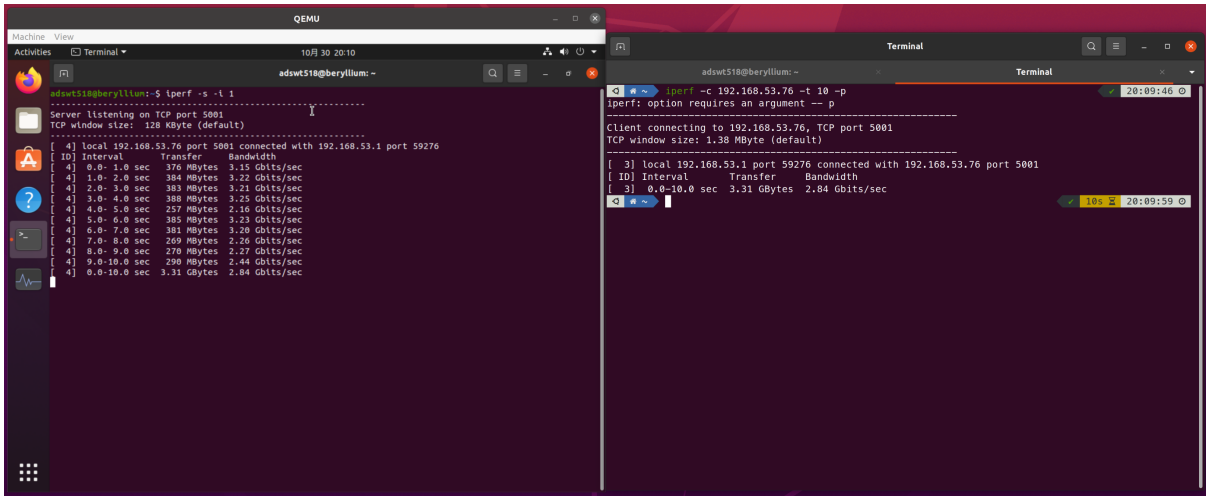

## 4 Compare the network (e1000 and virtio-net) performance of your host machine and VMs.

这里我使用iperf进行测试宿主机和QEMU虚拟机之间的网络表现。在QEMU虚拟机的终端中输入`iperf -s -i 1`，在宿主机的终端中输入`iperf -c 192.168.53.76 -t 10 -d`。

1. e1000下，平均带宽为1.35GB/s。




2. virtio-net下，平均带宽为2.84GB/s。




可以明显看出，与使用e1000时相比，使用virtio时，QEMU虚拟机的网络性能更好。

# 5 总结和反思

本次实验中，我首先尝试在物理机的Linux系统中直接安装QEMU并创建虚拟机，但由于我的笔记本电脑只有无线网卡，在设置无线网卡时遇到了一些困难，遂放弃，采用了VirtualBox+QEMU嵌套虚拟化的方法。

本次实验让我对QEMU有了初步的认识，也提高了解决问题的能力。

# 6 致谢

感谢我的同学陈浩南和刘梓睿对我的帮助，我在与他们的交流中，解决了很多问题。

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1. 在VirtualBox 6.1里面打开嵌套 VT-x_AMD-V 功能_holderlinzhang的博客-CSDN博客 https://blog.csdn.net/holderlinzhang/article/details/104260531 ↩

2. Hosts_Linux - QEMU https://wiki.qemu.org/Hosts/Linux ↩

3. 从源码编译安装QEMU以及如何创建QEMU虚拟机*Haifeng的博客-CSDN博客*源码安装qemu https://blog.csdn.net/haifeng_gu/article/details/108055083 ↩ ↩

4. Documentation_Networking_NAT - QEMU https://wiki.qemu.org/Documentation/Networking/NAT ↩

5. Documentation_Networking - QEMU https://wiki.qemu.org/Documentation/Networking ↩