# Task2

## Step1 - 编译模块

Bash

```
1 make LLVM=1
```

```
cicv-r4l-Lolioy/src_e1000 on  master via  v1.73.0
❯ make LLVM=1
make -C ../linux M=$PWD
make[1]: Entering directory '/home/lolioy/Workspace/rust/cicv-r4l-Lolioy/linux'
  RUSTC [M] /home/lolioy/Workspace/rust/cicv-r4l-Lolioy/src_e1000/r4l_e1000_demo.o
  MODPOST /home/lolioy/Workspace/rust/cicv-r4l-Lolioy/src_e1000/Module.symvers
  CC [M]  /home/lolioy/Workspace/rust/cicv-r4l-Lolioy/src_e1000/r4l_e1000_demo.mod.o
  LD [M]  /home/lolioy/Workspace/rust/cicv-r4l-Lolioy/src_e1000/r4l_e1000_demo.ko
make[1]: Leaving directory '/home/lolioy/Workspace/rust/cicv-r4l-Lolioy/linux'
```

## Step2 - 启动 Linux 系统

Bash

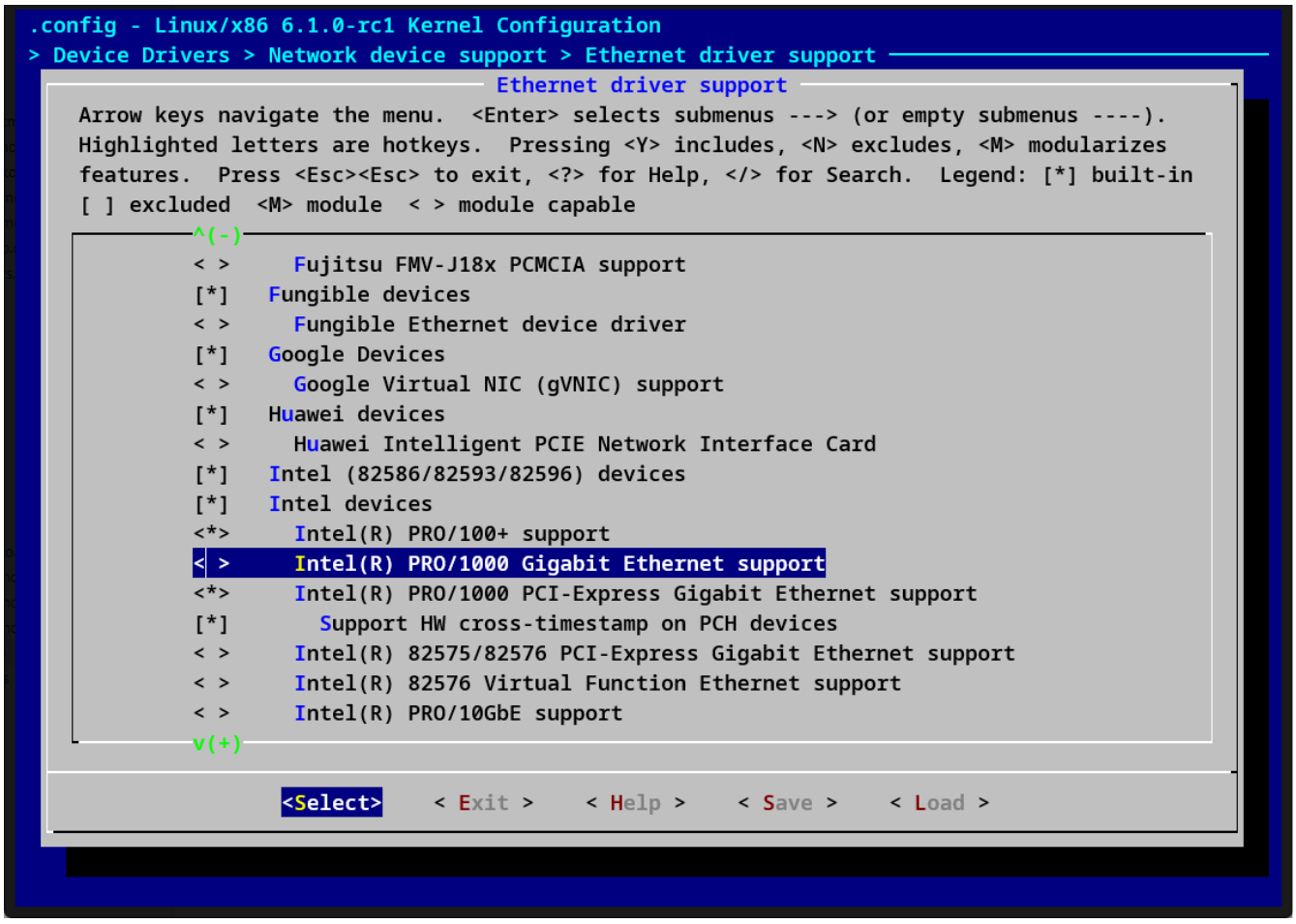
```
1 ./build_image.sh
```

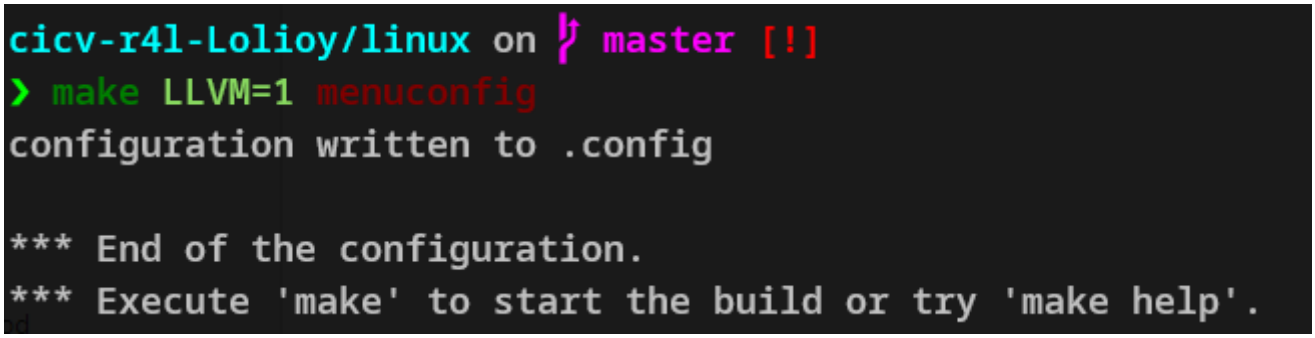
```
~ # ifconfig
eth0      Link encap:Ethernet  HWaddr 52:54:00:12:34:56
          inet addr:10.0.2.15  Bcast:10.0.2.255  Mask:255.255.255.0
          inet6 addr: fec0::5054:ff:fe12:3456/64 Scope:Site
          inet6 addr: fe80::5054:ff:fe12:3456/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:2 errors:0 dropped:0 overruns:0 frame:0
          TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:220 (220.0 B)  TX bytes:672 (672.0 B)
```

# Step3 - 禁用 E1000 网卡驱动

Bash

```
1 make LLVM=1 menuconfig
```

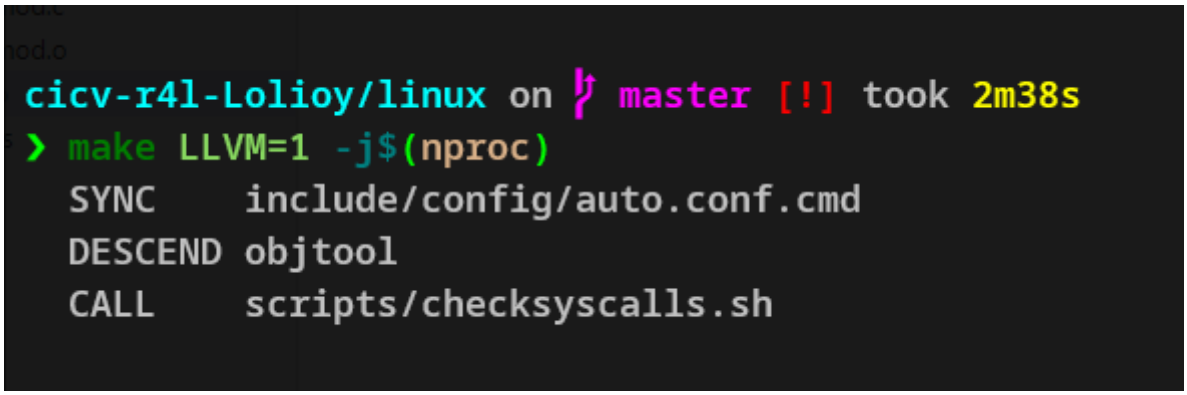


## Step4 - 重新编译 Linux 内核

Bash

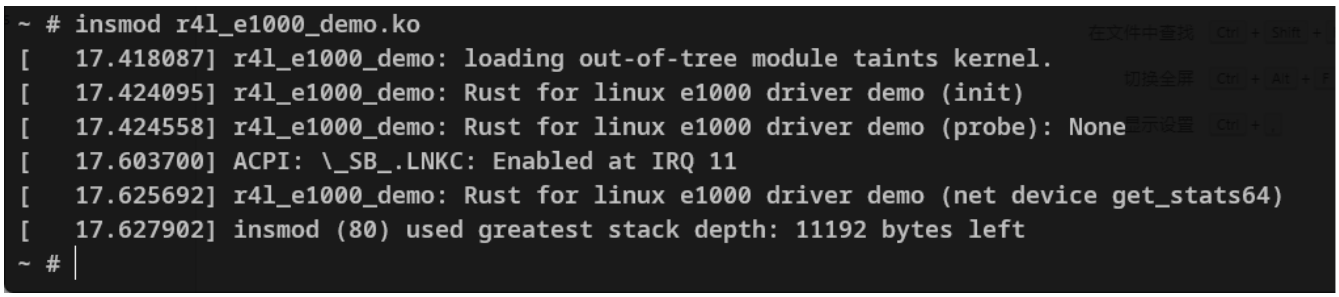
```
make LLVM=1 -j$(nproc)
```




## Step5 - 加载网络驱动模块

Bash

```
insmod r4l_e1000_demo.ko
```




## Step6 - 网络配置

Bash

```
ip link set eth0 up
ip addr add broadcast 10.0.2.255 dev eth0
ip addr add 10.0.2.15/255.255.255.0 dev eth0
ip route add default via 10.0.2.1
ping 10.0.2.2
```

```
[   93.536389] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=3, tdh=0
[   93.536940] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[   93.537272] r4l_e1000_demo: pending_irqs: 3
[   93.537571] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
[   93.538397] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=4, tdh=0
[   93.538741] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[   93.539244] r4l_e1000_demo: pending_irqs: 3
[   93.539931] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
[   94.559767] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=5, tdh=0
[   94.560524] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[   94.560992] r4l_e1000_demo: pending_irqs: 3
[   94.561342] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
[   97.439156] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=6, tdh=0
[   97.439848] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[   97.440234] r4l_e1000_demo: pending_irqs: 3
[   97.440693] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
[  105.567051] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=7, tdh=0
[  105.567541] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[  105.569116] r4l_e1000_demo: pending_irqs: 3
[  105.569332] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
[  121.438965] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=0, tdh=0
[  121.439713] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[  121.441625] r4l_e1000_demo: pending_irqs: 3
[  121.441904] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
[  156.767161] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=1, tdh=0
[  156.767517] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[  156.768009] r4l_e1000_demo: pending_irqs: 3
[  156.768175] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)

~ #
```

```
~ # ping 10.0.2.2
PING 10.0.2.2 (10.0.2.2): 56 data bytes
[  551.360319] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=7, tdh=3
[  551.360952] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[  551.361168] r4l_e1000_demo: pending_irqs: 131
[  551.361353] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
64 bytes from 10.0.2.2: seq=0 ttl=255 time=2.206 ms
[  552.362816] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=0, tdh=4
[  552.363127] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[  552.363885] r4l_e1000_demo: pending_irqs: 131
[  552.364156] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
64 bytes from 10.0.2.2: seq=1 ttl=255 time=2.024 ms
[  553.365390] r4l_e1000_demo: Rust for linux e1000 driver demo (net device start_xmit) tdt=1, tdh=5
[  553.365849] r4l_e1000_demo: Rust for linux e1000 driver demo (handle_irq)
[  553.366413] r4l_e1000_demo: pending_irqs: 131
[  553.366551] r4l_e1000_demo: Rust for linux e1000 driver demo (napi poll)
64 bytes from 10.0.2.2: seq=2 ttl=255 time=2.237 ms
^C
--- 10.0.2.2 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 2.024/2.155/2.237 ms
```

# Q & A

## Q1: 编译成内核模块，是在哪个文件中以哪条语句定义的？

在 `src_e1000/Kbuild` 文件中，通过 `obj-m := r4l_e1000_demo.o` 语句定义的.

Kbuild 文件是用于构建内核模块的专用构建文件。它定义了编译模块的规则和指令，以及模块的依赖关系和安装路径等信息。每个内核模块都应该有自己的 Kbuild 文件，用于描述模块的构建和安装过程。

## Q2: 该模块位于独立的文件夹内，却能编译成 Linux 内核模块，这叫做 out-of-tree module，请分析它是如何与内核代码产生联系的？

1. 在 `src_e1000/Makefile` 文件中，指定了内核源代码树的路径：`$(MAKE) -C $(KDIR) M=$$PWD`，其中 `$(KDIR)` 指向了上层目录下的 `linux` 目录
2. `make` 命令会根据 `Kbuild` 文件中的规则编译模块，并生成目标文件和模块文件
3. 进入 Linux 系统后，加载模块 `insmod r4l_e1000_demo.ko`