

# 数据通信作业

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## 数据通信作业

### 一、实验名称及内容

#### 二、实验过程和结果

环境

实验过程

实验结果

第一题

第二题

### 三、问题与思考

## 一、实验名称及内容

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名称： **ns3** 实现网络结构通信：    192.168.10.0    192.168.50.0

n0 ----- n1----- n2

point-to-point    point-to-point

5Mbps, 2ms    1Mbps, 2ms

## 二、实验过程和结果

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### 环境

物理主机系统： *macOS Catalina 10.15.4*

虚拟机系统： *Ubuntu 18.04.4 LTS*

虚拟机软件： *VMware Fusion 专业版 11.5.3 (15870345)*

实验软件： *ns-3.28*

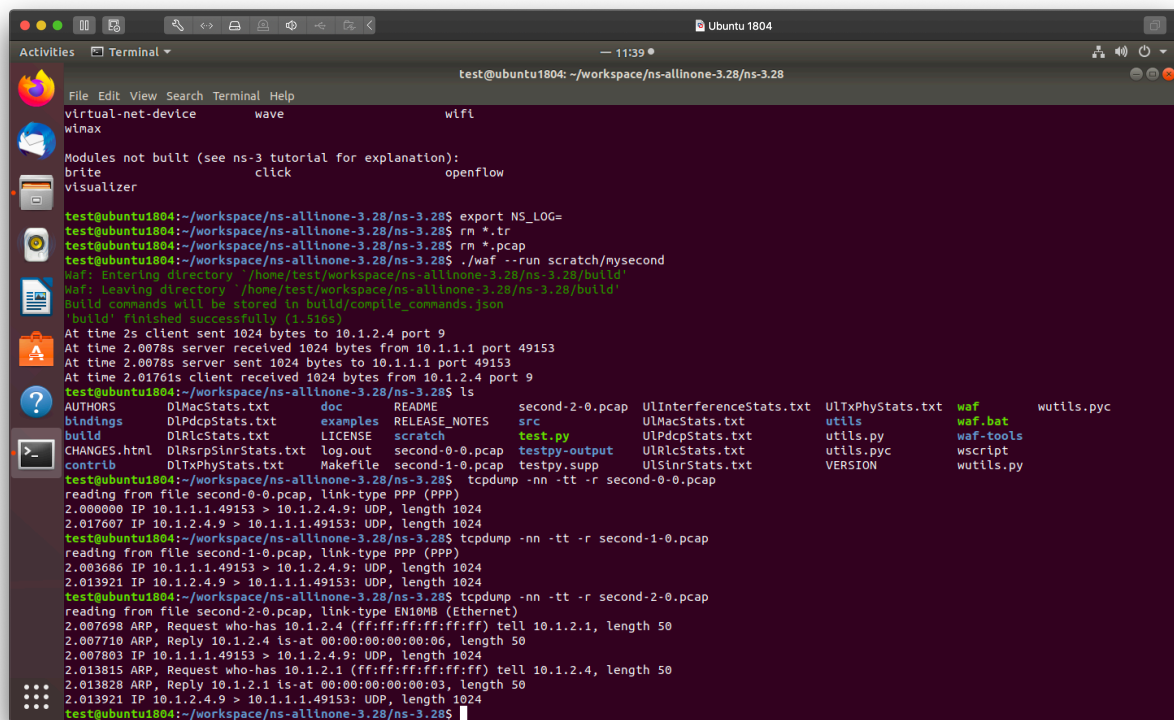
### 实验过程

1. 第一题按实验指导书完成
2. 第二题仿造之前的 **ns3** 程序，按模块编程：
  1. 确定 **LOG** 格式
  2. 创建三个节点
  3. 创建并配置通信链路
  4. 在节点上安装网卡
  5. 在节点上安装通信协议栈

6. 创建并配置发包与收包应用程序
7. 开始仿真
8. 结束仿真
9. 查看输出
10. 查看 **pcap**

## 实验结果

### 第一题



```
test@ubuntu1804: ~/workspace/ns-allinone-3.28/ns-3.28
virtual-net-device      wave      wifi
winmax

Modules not built (see ns-3 tutorial for explanation):
brute      click      openflow
visualizer

test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ export NS_LOG=
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ rm *.tr
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ rm *.pcap
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ ./waf --run scratch/mysecond
Waf: Entering directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
Waf: Leaving directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
build commands will be stored in build/compile_commands.json
'build' finished successfully (0.51s)
At time 2s client sent 1024 bytes to 10.1.2.4 port 9
At time 2.0078s server received 1024 bytes from 10.1.1.1 port 49153
At time 2.0078s server sent 1024 bytes to 10.1.1.1 port 49153
At time 2.01761s client received 1024 bytes from 10.1.2.4 port 9
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ ls
AUTHORS      DLMacStats.txt      doc      README      second-2-0.pcap      ULInterferenceStats.txt      ULTxPhyStats.txt      waf      wutils.pyc
bindings     DLPdcpStats.txt     examples  RELEASE_NOTES      src      ULMacStats.txt      ULPdcStats.txt      utils      waf.bat
build        DLRlcStats.txt      LICENSE   scratch           test.py   ULPdcStats.txt      ULRLcStats.txt      utils.py   waf-tools
CHANGES.html  DLRsrpSInrStats.txt log.out   second-0-0.pcap    testpy-output      testpy-suppl      ULRLcStats.txt      utils.pyc  wscript
contrib       DLTxPhyStats.txt    Makefile  second-1-0.pcap    testpy-suppl      ULRLcStats.txt      ULRLcStats.txt      VERSION   wutils.py
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ tcpdump -nn -tt -r second-0-0.pcap
reading from file second-0-0.pcap, link-type PPP (PPP)
2.000000 IP 10.1.1.1.49153 > 10.1.2.4.9: UDP, length 1024
2.017607 IP 10.1.2.4.9 > 10.1.1.1.49153: UDP, length 1024
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ tcpdump -nn -tt -r second-1-0.pcap
reading from file second-1-0.pcap, link-type PPP (PPP)
2.003686 IP 10.1.1.1.49153 > 10.1.2.4.9: UDP, length 1024
2.013921 IP 10.1.2.4.9 > 10.1.1.1.49153: UDP, length 1024
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ tcpdump -nn -tt -r second-2-0.pcap
reading from file second-2-0.pcap, link-type EN10MB (Ethernet)
2.007698 ARP, Request who-has 10.1.2.4 (ff:ff:ff:ff:ff:ff) tell 10.1.2.1, length 50
2.007710 ARP, Reply 10.1.2.4 is-at 00:00:00:00:00:06, length 50
2.007803 IP 10.1.1.1.49153 > 10.1.2.4.9: UDP, length 1024
2.013815 ARP, Request who-has 10.1.2.1 (ff:ff:ff:ff:ff:ff) tell 10.1.2.4, length 50
2.013828 ARP, Reply 10.1.2.1 is-at 00:00:00:00:00:03, length 50
2.013921 IP 10.1.2.4.9 > 10.1.1.1.49153: UDP, length 1024
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$
```

### 第二题

查看应用程序配置。

```
test@ubuntu1804: ~/workspace/ns-allinone-3.28/ns-3.28
Modules built:
antenna          aodv          applications
bridge           buildings     config-store
core             csma          csma-layout
dsv             dsr           energy
fd-net-device    flow-monitor internet
internet-apps   lr-wpan      lte
mesh            mobility     mpi
netanim (no Python) network      nix-vector-routing
olsr            point-to-point point-to-point-layout
propagation      sixlowpan    spectrum
stats           tap-bridge   test (no Python)
topology-read    traffic-control uan
virtual-net-device wave         wifi
winax

Modules not built (see ns-3 tutorial for explanation):
brte          click          openflow
visualizer

test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ ./waf --run "scratch/lab2 --PrintAttributes=ns3::OnOffApplication"
waf: Entering directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
waf: Leaving directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.891s)

Attributes for TypeId ns3::OnOffApplication
--ns3::OnOffApplication::DataRate=[500000bps]
  The data rate in on state.
--ns3::OnOffApplication::MaxBytes=[0]
  The total number of bytes to send. Once these bytes are sent, no packet is sent again, even in on state. The value zero means that there is no limit.
--ns3::OnOffApplication::OffTime=[ns3::ConstantRandomVariable[Constant=1.0]]
  A RandomVariableStream used to pick the duration of the 'Off' state.
--ns3::OnOffApplication::OnTime=[ns3::ConstantRandomVariable[Constant=1.0]]
  A RandomVariableStream used to pick the duration of the 'On' state.
--ns3::OnOffApplication::PacketSize=[512]
  The size of packets sent in on state.
--ns3::OnOffApplication::Protocol=[ns3::UdpSocketFactory]
  The type of protocol to use. This should be a subclass of ns3::SocketFactory
--ns3::OnOffApplication::Remote=[00-00-00]
  The address of the destination
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$
```

运行仿真程序，查看屏幕输出，与要求输出相符。

```
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ ./waf
waf: Entering directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
[ 982/2588] Compiling scratch/lab2.cc
[2575/2588] Linking build/scratch/lab2
waf: Leaving directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (5.192s)

Modules built:
antenna          aodv          applications
bridge           buildings     config-store
core             csma          csma-layout
dsv             dsr           energy
fd-net-device    flow-monitor internet
internet-apps   lr-wpan      lte
mesh            mobility     mpi
netanim (no Python) network      nix-vector-routing
olsr            point-to-point point-to-point-layout
propagation      sixlowpan    spectrum
stats           tap-bridge   test (no Python)
topology-read    traffic-control uan
virtual-net-device wave         wifi
winax

Modules not built (see ns-3 tutorial for explanation):
brte          click          openflow
visualizer

test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$ ./waf --run scratch/lab2
waf: Entering directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
waf: Leaving directory '/home/test/workspace/ns-allinone-3.28/ns-3.28/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (1.372s)
At time 2.08192s on-off application sent 512 bytes to 192.168.50.2 port 12345 total Tx 512 bytes
At time 2.09135s packet sink received 512 bytes from 192.168.10.1 port 49153 total Rx 512 bytes
At time 2.16384s on-off application sent 512 bytes to 192.168.50.2 port 12345 total Tx 1024 bytes
At time 2.17327s packet sink received 512 bytes from 192.168.10.1 port 49153 total Rx 1024 bytes
At time 2.24576s on-off application sent 512 bytes to 192.168.50.2 port 12345 total Tx 1536 bytes
At time 2.32768s on-off application sent 512 bytes to 192.168.50.2 port 12345 total Tx 2048 bytes
At time 2.38746s packet sink received 536 bytes from 192.168.10.1 port 49153 total Rx 1568 bytes
At time 2.39179s packet sink received 488 bytes from 192.168.10.1 port 49153 total Rx 2048 bytes
test@ubuntu1804:~/workspace/ns-allinone-3.28/ns-3.28$
```

查看各节点记录的pcap包。

```
Activities Terminal 12:05 Ubuntu 1804
File Edit View Search Terminal Help
At time 2.39179s packet sink received 488 bytes from 192.168.10.1 port 49153 total Rx 2048 bytes
test@ubuntu1804:~/workspace/ns-allInOne-3.28/ns-3.28$ wireshark Lab2-0-0.pcap
test@ubuntu1804:~/workspace/ns-allInOne-3.28/ns-3.28$ tcpdump -nn -tt -r Lab2-0-0.pcap
reading from file Lab2-0-0.pcap, link-type PPP (PPP)
2.000000 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [S], seq 0, win 65535, options [TS val 2000 ecr 0,wscale 2,sackOK,eol], length 0
2.009113 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [S.], seq 0, ack 1, win 65535, options [TS val 2004 ecr 2000,wscale 2,sackOK,eol], length 0
2.009113 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], ack 1, win 32768, options [TS val 2009 ecr 2004,eol], length 0
2.081920 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 1:513, ack 1, win 32768, options [TS val 2081 ecr 2004,eol], length 512
2.095871 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 513, win 32768, options [TS val 2091 ecr 2081,eol], length 0
2.163840 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 513:1025, ack 1, win 32768, options [TS val 2163 ecr 2091,eol], length 512
2.377791 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 1025, win 32768, options [TS val 2373 ecr 2163,eol], length 0
2.377791 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 1025:1561, ack 1, win 32768, options [TS val 2377 ecr 2373,eol], length 536
2.378735 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [F.], seq 1561:2049, ack 1, win 32768, options [TS val 2377 ecr 2373,eol], length 488
2.396310 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 2050, win 32768, options [TS val 2391 ecr 2377,eol], length 0
2.396742 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [F.], seq 1, ack 2050, win 32768, options [TS val 2391 ecr 2377,eol], length 0
2.396742 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], ack 2, win 32768, options [TS val 2396 ecr 2391,eol], length 0
test@ubuntu1804:~/workspace/ns-allInOne-3.28/ns-3.28$ tcpdump -nn -tt -r Lab2-1-0.pcap
reading from file Lab2-1-0.pcap, link-type PPP (PPP)
2.002092 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [S], seq 0, win 65535, options [TS val 2000 ecr 0,wscale 2,sackOK,eol], length 0
2.007020 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [S.], seq 0, ack 1, win 65535, options [TS val 2004 ecr 2000,wscale 2,sackOK,eol], length 0
2.011199 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], ack 1, win 32768, options [TS val 2009 ecr 2004,eol], length 0
2.084825 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 1:513, ack 1, win 32768, options [TS val 2081 ecr 2004,eol], length 512
2.093785 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 513, win 32768, options [TS val 2091 ecr 2081,eol], length 0
2.160745 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 513:1025, ack 1, win 32768, options [TS val 2163 ecr 2091,eol], length 512
2.375705 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 1025, win 32768, options [TS val 2373 ecr 2163,eol], length 0
2.380735 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 1025:1561, ack 1, win 32768, options [TS val 2377 ecr 2373,eol], length 536
2.381603 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [F.], seq 1561:2049, ack 1, win 32768, options [TS val 2377 ecr 2373,eol], length 488
2.394223 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 2050, win 32768, options [TS val 2391 ecr 2377,eol], length 0
2.394655 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [F.], seq 1, ack 2050, win 32768, options [TS val 2391 ecr 2377,eol], length 0
2.398828 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], ack 2, win 32768, options [TS val 2396 ecr 2391,eol], length 0
test@ubuntu1804:~/workspace/ns-allInOne-3.28/ns-3.28$ tcpdump -nn -tt -r Lab2-2-0.pcap
reading from file Lab2-2-0.pcap, link-type PPP (PPP)
2.004556 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [S], seq 0, win 65535, options [TS val 2000 ecr 0,wscale 2,sackOK,eol], length 0
2.004556 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [S.], seq 0, ack 1, win 65535, options [TS val 2004 ecr 2000,wscale 2,sackOK,eol], length 0
2.013631 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], ack 1, win 32768, options [TS val 2009 ecr 2004,eol], length 0
2.091353 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 1:513, ack 1, win 32768, options [TS val 2081 ecr 2004,eol], length 512
2.091353 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 513, win 32768, options [TS val 2091 ecr 2081,eol], length 0
2.173273 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 513:1025, ack 1, win 32768, options [TS val 2163 ecr 2091,eol], length 512
2.373273 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 1025, win 32768, options [TS val 2373 ecr 2163,eol], length 0
2.387455 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], seq 1025:1561, ack 1, win 32768, options [TS val 2377 ecr 2373,eol], length 536
2.391791 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [F.], seq 1561:2049, ack 1, win 32768, options [TS val 2377 ecr 2373,eol], length 488
2.391791 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [..], ack 2050, win 32768, options [TS val 2391 ecr 2377,eol], length 0
2.392223 IP 192.168.50.2.12345 > 192.168.10.1.49153: Flags [F.], seq 1, ack 2050, win 32768, options [TS val 2391 ecr 2377,eol], length 0
2.401260 IP 192.168.10.1.49153 > 192.168.50.2.12345: Flags [..], ack 2, win 32768, options [TS val 2396 ecr 2391,eol], length 0
test@ubuntu1804:~/workspace/ns-allInOne-3.28/ns-3.28$
```

### 三、问题与思考

这次实验由于要自己动手，比之前的难了不少。但在学习的过程中，我发现 **ns3** 编程的特点非常像 **winsock** 编程，即模块化编程。LOG 模块，节点模块，通信链路模块，网卡模块，应用程序模块，相互独立。这种模块化的编程方式让 **ns3** 编程简单了不少，只要去看已有的例程，模仿它们各模块的特点，编程就变得很简单了。