数据通信 NS3 作业-2

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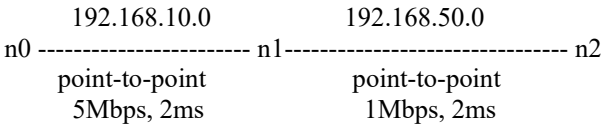
一、 实验名称及内容

Lab2:

Build a 2-hop Point-to-Point network as illustrated below,



- n0 sends a total number of 2000 bytes to n2.
- Use onoff-application (TCP) on n0 with packet size 512, data rate 50kb/s, set the OnTime random variable to 1 and OffTime random variable to 0.
- Use PacketSink (TCP) application on n2 to receive the packets.
- Enable NS_LOG on both onoff-application and PacketSink, turn on pacp tracing on all nodes.
- Use filename: lab2.cc

Hints: For onoff-application and packet-sink application, the source codes are in /home/workspace/ns-allinone-3.28/ns-3.28/src/applications/model. Or go to https://www.nsnam.org/doxygen/index.html, click Modules→Applications→OnOffApplication to see a detailed description of the application.

二、 实验过程和结果

程序见压缩包内。本次 ns3 的版本为 3.30。

Simulation：

1. $find . -name '*.cc' | xargs grep OnOffApplication | grep example

```
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ find . -name '*.cc' | xargs grep OnOffApplication | grep example
./src/mpi/examples/simple-distributed.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (512));
./src/mpi/examples/simple-distributed.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("1Mbps"));
./src/mpi/examples/simple-distributed.cc:  Config::SetDefault ("ns3::OnOffApplication::MaxBytes", UintegerValue (512));
./src/mpi/examples/nms-p2p-nix-distributed.cc:  Config::SetDefault ("ns3::OnOffApplication::MaxBytes",
./src/mpi/examples/nms-p2p-nix-distributed.cc:  Config::SetDefault ("ns3::OnOffApplication::OnTime",
./src/mpi/examples/nms-p2p-nix-distributed.cc:  Config::SetDefault ("ns3::OnOffApplication::OffTime",
./src/mpi/examples/simple-distributed-empty-node.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (512));
./src/mpi/examples/simple-distributed-empty-node.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("1Mbps"));
./src/mpi/examples/simple-distributed-empty-node.cc:  Config::SetDefault ("ns3::OnOffApplication::MaxBytes", UintegerValue (512));
./src/tap-bridge/examples/tap-wifi-dumbbell.cc://    link and watch the ping timing change.  The OnOffApplication "DataRate"
./src/tap-bridge/examples/tap-wifi-dumbbell.cc://    ./waf --run "tap-wifi-dumbbell --ns3::OnOffApplication::DataRate=100kb/s"&
./src/virtual-net-device/examples/virtual-net-device.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (210));
./src/virtual-net-device/examples/virtual-net-device.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("448kb/s"));
./src/netanim/examples/dumbbell-animation.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (512));
./src/netanim/examples/dumbbell-animation.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("500kb/s"));
./src/netanim/examples/colors-link-description.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (512));
./src/netanim/examples/colors-link-description.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("500kb/s"));
./src/netanim/examples/resources-counters.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (512));
./src/netanim/examples/resources-counters.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("500kb/s"));
./src/netanim/examples/star-animation.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (137));
./src/netanim/examples/star-animation.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("14kb/s"));
./src/netanim/examples/grid-animation.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (512));
./src/netanim/examples/grid-animation.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("500kb/s"));
./src/traffic-control/examples/pfifo-vs-red.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (pktSize));
./src/traffic-control/examples/pfifo-vs-red.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue (appDataRate));
./src/traffic-control/examples/red-vs-ared.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", UintegerValue (pktSize));
./src/traffic-control/examples/red-vs-ared.cc:  Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue (appDataRate));
./src/nix-vector-routing/examples/nms-p2p-nix.cc:  // LogComponentEnable ("OnOffApplication", LOG_LEVEL_INFO);
./src/nix-vector-routing/examples/nms-p2p-nix.cc:  Config::SetDefault ("ns3::OnOffApplication::MaxBytes", UintegerValue (500000));
./src/nix-vector-routing/examples/nms-p2p-nix.cc:  Config::SetDefault ("ns3::OnOffApplication::OnTime",
./src/nix-vector-routing/examples/nms-p2p-nix.cc:  Config::SetDefault ("ns3::OnOffApplication::OffTime",
./src/dsdv/examples/dsdv-manet.cc:  Config::SetDefault ("ns3::OnOffApplication::PacketSize", StringValue ("1000"));
```

2. $./waf --run "scratch/mysecond --PrintAttributes=ns3::OnOffApplication"

```
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ ./waf --run "scratch/mysecond --Prin
tAttributes=ns3::OnOffApplication"
Waf: Entering directory `/home/fy/tarballs/ns-3-allinone/ns-3.30/build'
Waf: Leaving directory `/home/fy/tarballs/ns-3-allinone/ns-3.30/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (2.144s)
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::SocketFac
tory
    --ns3::OnOffApplication::Remote=[00-00-00]
        The address of the destination
```

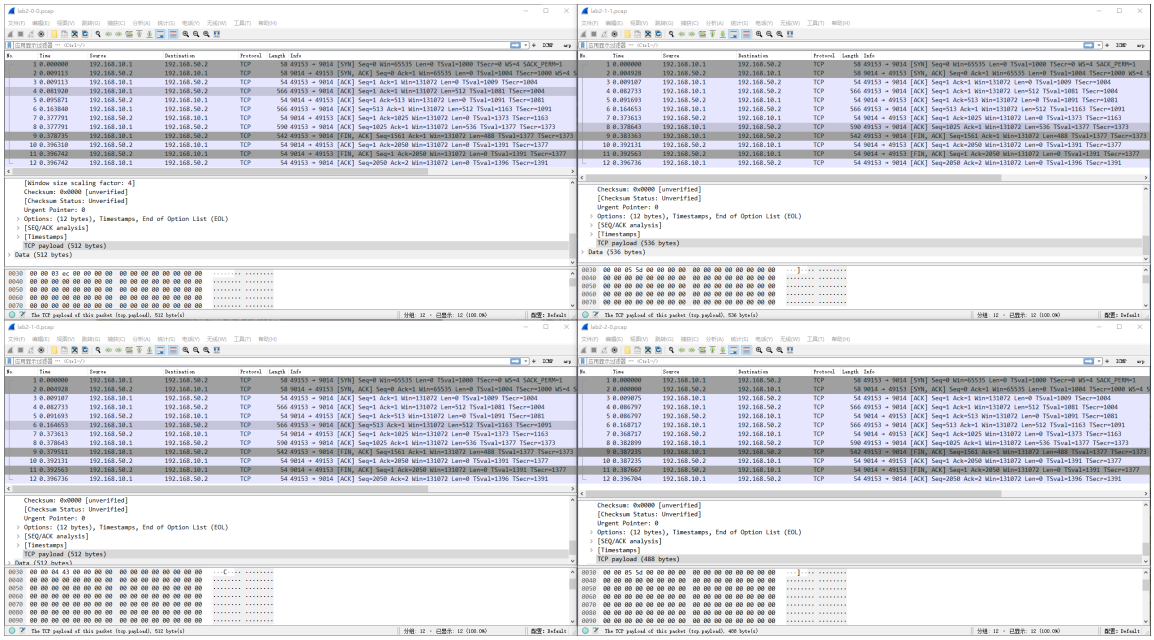
3. $./waf --run scratch/lab2

```
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ ./waf --run scratch/csma
Waf: Entering directory `/home/fy/tarballs/ns-3-allinone/ns-3.30/build'
Waf: Leaving directory `/home/fy/tarballs/ns-3-allinone/ns-3.30/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (22.127s)
At time 1.08192s on-off application sent 512 bytes to 192.168.50.2 port 9014 total Tx 512 bytes
At time 1.09135s packet sink received 512 bytes from 192.168.10.1 port 49153 total Rx 512 bytes
At time 1.16384s on-off application sent 512 bytes to 192.168.50.2 port 9014 total Tx 1024 bytes
At time 1.17327s packet sink received 512 bytes from 192.168.10.1 port 49153 total Rx 1024 bytes
At time 1.24576s on-off application sent 512 bytes to 192.168.50.2 port 9014 total Tx 1536 bytes
At time 1.32768s on-off application sent 512 bytes to 192.168.50.2 port 9014 total Tx 2048 bytes
At time 1.38746s packet sink received 536 bytes from 192.168.10.1 port 49153 total Rx 1560 bytes
At time 1.39179s packet sink received 488 bytes from 192.168.10.1 port 49153 total Rx 2048 bytes
```

4. pcap file contents to show that packets are delivered to the destination

```
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ sudo tcpdump -nn -tt -r lab2-0-0.pcap
reading from file lab2-0-0.pcap, link-type PPP (PPP)
1.000000 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [S], seq 0, win 65535, options [TS val 1000 ecr 0,wscale 2,sackOK,eol], length 0
1.009113 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [S.], seq 0, ack 1, win 65535, options [TS val 1004 ecr 1000,wscale 2,sackOK,eol], length 0
1.009113 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 1, win 32768, options [TS val 1009 ecr 1004,eol], length 0
1.081920 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1:513, ack 1, win 32768, options [TS val 1081 ecr 1004,eol], length 512
1.095871 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 513, win 32768, options [TS val 1091 ecr 1081,eol], length 0
1.163840 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 513:1025, ack 1, win 32768, options [TS val 1163 ecr 1091,eol], length 512
1.377791 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 1025, win 32768, options [TS val 1373 ecr 1163,eol], length 0
1.377791 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1025:1561, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 536
1.378735 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [F.], seq 1561:2049, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 488
1.396310 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.396742 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [F.], seq 1, ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.396742 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 2, win 32768, options [TS val 1396 ecr 1391,eol], length 0
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ sudo tcpdump -nn -tt -r lab2-1-0.pcap
reading from file lab2-1-0.pcap, link-type PPP (PPP)
1.002092 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [S], seq 0, win 65535, options [TS val 1000 ecr 0,wscale 2,sackOK,eol], length 0
1.007020 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [S.], seq 0, ack 1, win 65535, options [TS val 1004 ecr 1000,wscale 2,sackOK,eol], length 0
1.011199 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 1, win 32768, options [TS val 1009 ecr 1004,eol], length 0
1.084825 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1:513, ack 1, win 32768, options [TS val 1081 ecr 1004,eol], length 512
1.093785 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 513, win 32768, options [TS val 1091 ecr 1081,eol], length 0
1.166745 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 513:1025, ack 1, win 32768, options [TS val 1163 ecr 1091,eol], length 512
1.375705 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 1025, win 32768, options [TS val 1373 ecr 1163,eol], length 0
1.380735 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1025:1561, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 536
1.381603 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [F.], seq 1561:2049, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 488
1.394223 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.394655 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [F.], seq 1, ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.398828 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 2, win 32768, options [TS val 1396 ecr 1391,eol], length 0
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ sudo tcpdump -nn -tt -r lab2-1-1.pcap
reading from file lab2-1-1.pcap, link-type PPP (PPP)
1.002092 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [S], seq 0, win 65535, options [TS val 1000 ecr 0,wscale 2,sackOK,eol], length 0
1.007020 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [S.], seq 0, ack 1, win 65535, options [TS val 1004 ecr 1000,wscale 2,sackOK,eol], length 0
1.011199 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 1, win 32768, options [TS val 1009 ecr 1004,eol], length 0
1.084825 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1:513, ack 1, win 32768, options [TS val 1081 ecr 1004,eol], length 512
1.093785 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 513, win 32768, options [TS val 1091 ecr 1081,eol], length 0
1.166745 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 513:1025, ack 1, win 32768, options [TS val 1163 ecr 1091,eol], length 512
1.375705 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 1025, win 32768, options [TS val 1373 ecr 1163,eol], length 0
1.380735 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1025:1561, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 536
1.385455 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [F.], seq 1561:2049, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 488
1.394223 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.394655 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [F.], seq 1, ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.398828 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 2, win 32768, options [TS val 1396 ecr 1391,eol], length 0
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ sudo tcpdump -nn -tt -r lab2-2-0.pcap
reading from file lab2-2-0.pcap, link-type PPP (PPP)
1.004556 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [S], seq 0, win 65535, options [TS val 1000 ecr 0,wscale 2,sackOK,eol], length 0
1.004556 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [S.], seq 0, ack 1, win 65535, options [TS val 1004 ecr 1000,wscale 2,sackOK,eol], length 0
1.013631 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 1, win 32768, options [TS val 1009 ecr 1004,eol], length 0
1.091353 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1:513, ack 1, win 32768, options [TS val 1081 ecr 1004,eol], length 512
1.091353 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 513, win 32768, options [TS val 1091 ecr 1081,eol], length 0
1.173273 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 513:1025, ack 1, win 32768, options [TS val 1163 ecr 1091,eol], length 512
1.373273 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 1025, win 32768, options [TS val 1373 ecr 1163,eol], length 0
1.387455 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], seq 1025:1561, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 536
1.391791 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [F.], seq 1561:2049, ack 1, win 32768, options [TS val 1377 ecr 1373,eol], length 488
1.391791 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [.], ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.392223 IP 192.168.50.2.9014 > 192.168.10.1.49153: Flags [F.], seq 1, ack 2050, win 32768, options [TS val 1391 ecr 1377,eol], length 0
1.401260 IP 192.168.10.1.49153 > 192.168.50.2.9014: Flags [.], ack 2, win 32768, options [TS val 1396 ecr 1391,eol], length 0
```

5. Check in Wireshark:



三、 实验思考：

- **关于 512 分片中出现 536 和 488 长度分组的情况：**

  分析是由于默认 ns-3 的 TCP 分段长度为 536，猜测是按断续发送 512 长度，在最后一段发送时整个发送了 1024 长度的报文，默认分片成 536，剩余 488 分组。

```
// ns-3 TCP default segment size of 536
riterStopTimeObj, &SocketWriter::Close, socketWriter);
```