

数据通信 NS3 作业-3

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一、 实验名称及内容

Lab3:

- ✚ Create three access point A, B and C. Wire (Connect) A-B, B-C using point to point link (100Mbps, 2ms).
- ✚ Create three client nodes (mobile stations) for access points A and C, respectively, and allow them to move according to Random Walk mobility model.
- ✚ Install UdpEchoClient on a node associated with access point A, and install UdpEchoServer on a node connected to C.
- ✚ Let UdpEchoClient send a total number of 2 packets to the UdpEchoServer, with an Interval of 1 second, and PacketSize of 1024 bytes.
- ✚ Generate the traces using packet capture.

Topology:

```
// | | | | 10.1.1.0 10.1.2.0
// n3 n4 n5 n0 ----- n1 ----- n2 n6 n7 n8
// point-to-point point-to-point | | | |
// 100Mbps 2ms 100Mbps 2ms * * * *
// AP
// Wifi 10.1.4.0
```

二、实验过程和结果

程序见压缩包内。本次 ns3 的版本为 3.30。

```
#include "ns3/core-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/network-module.h"
#include "ns3/applications-module.h"
#include "ns3/mobility-module.h"
#include "ns3/csma-module.h"
#include "ns3/internet-module.h"
#include "ns3/yans-wifi-helper.h"
#include "ns3/ssid.h"
```

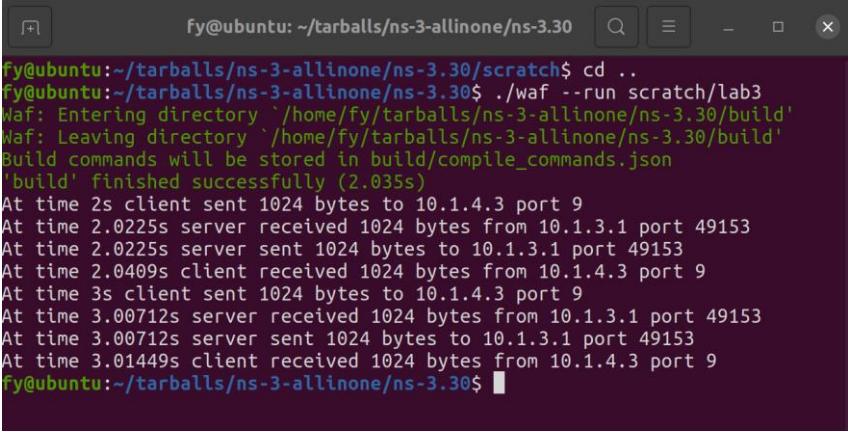
头文件包含内容如上。

本次实验的主要内容是设置 WiFi 网络，需要添加 AP 和 Random Walk mobility model。

- 首先建立两个 p2p 模型和三个节点 n0, n1, n2, 设置 p2p 的参数;
- 然后配置 wifi 网络, 配置物理层, MAC 层等;
- 安装 mobility 模型, 配置协议, 设置 IP 地址;
- 最后建立 Server 和 Client, 传输 UDP 数据包。

Simulation:

1) *./waf --run scratch/lab3:*



```
fy@ubuntu: ~/tarballs/ns-3-allinone/ns-3.30
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30/scratch$ cd ..
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ ./waf --run scratch/lab3
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 (2.035s)
At time 2s client sent 1024 bytes to 10.1.4.3 port 9
At time 2.0225s server received 1024 bytes from 10.1.3.1 port 49153
At time 2.0225s server sent 1024 bytes to 10.1.3.1 port 49153
At time 2.0409s client received 1024 bytes from 10.1.4.3 port 9
At time 3s client sent 1024 bytes to 10.1.4.3 port 9
At time 3.00712s server received 1024 bytes from 10.1.3.1 port 49153
At time 3.00712s server sent 1024 bytes to 10.1.3.1 port 49153
At time 3.01449s client received 1024 bytes from 10.1.4.3 port 9
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$
```

2) tcpdump -nn -tt -r lab3-0-0.pcap

Traces at access point A: A 点是 n0, 为 p2pNodes1, 对应的 pcap 文件为 lab3-00.pcap。

```
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ tcpdump -nn -tt -r lab3-0-0.pcap
reading from file lab3-0-0.pcap, link-type PPP (PPP)
2.009304 IP 10.1.3.1.49153 > 10.1.4.3.9: UDP, length 1024
2.033908 IP 10.1.4.3.9 > 10.1.3.1.49153: UDP, length 1024
3.001476 IP 10.1.3.1.49153 > 10.1.4.3.9: UDP, length 1024
3.013010 IP 10.1.4.3.9 > 10.1.3.1.49153: UDP, length 1024
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$
```

可以看出是 n3 节点发给 n8, 长度为 1024 字节的 UDP 包, 在 2s 和 3s 各发一次。

3) tcpdump -nn -tt -r lab3-3-0.pcap & lab3-8-0.pcap

```
fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ tcpdump -nn -tt -r lab3-3-0.pcap
reading from file lab3-3-0.pcap, link-type IEEE802.11 (802.11)
0.067208 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.120000 Assoc Request (WLAN-SSID-1) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.120426 Assoc Request (WLAN-SSID-1) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.120486 Acknowledgment RA:00:00:00:00:00:00
0.120761 Assoc Request (WLAN-SSID-1) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.120761 Acknowledgment RA:00:00:00:00:00:00
0.120831 Assoc Request (WLAN-SSID-1) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.120991 Acknowledgment RA:00:00:00:00:00:00
0.121118 Assoc Response AID(1) :: Successful
0.121178 Acknowledgment RA:00:00:00:00:00:00
0.121332 Assoc Response AID(2) :: Successful
0.121392 Acknowledgment RA:00:00:00:00:00:00
0.121591 Assoc Response AID(3) :: Successful
0.121607 Acknowledgment RA:00:00:00:00:00:00
0.169608 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.272008 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.374408 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.476808 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.579208 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.681608 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.784008 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.886408 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.988808 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.091208 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.193608 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.296008 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.398408 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.500808 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.603208 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.705608 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.808008 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.910408 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.007800 ARP, Request who-has 10.1.3.4 (ff:ff:ff:ff:ff:ff) tell 10.1.3.1, length 32
2.007772 Acknowledgment RA:00:00:00:00:00:00
2.007399 ARP, Request who-has 10.1.3.4 (ff:ff:ff:ff:ff:ff) tell 10.1.3.1, length 32
2.007680 ARP, Reply 10.1.3.4 is-at 00:00:00:00:00:00, length 32
2.007696 Acknowledgment RA:00:00:00:00:00:00
2.007828 IP 10.1.3.1.49153 > 10.1.4.3.9: UDP, length 1024
2.009364 Acknowledgment RA:00:00:00:00:00:00
2.012808 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.039620 ARP, Request who-has 10.1.3.1 (ff:ff:ff:ff:ff:ff) tell 10.1.3.4, length 32
2.039162 ARP, Reply 10.1.3.1 is-at 00:00:00:00:00:00, length 32
2.039334 Acknowledgment RA:00:00:00:00:00:00
2.040898 IP 10.1.4.3.9 > 10.1.3.1.49153: UDP, length 1024
2.040914 Acknowledgment RA:00:00:00:00:00:00
2.115208 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.217608 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.320008 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.422408 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.524808 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.627208 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.729608 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.832008 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.934408 Beacon (WLAN-SSID-1) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
3.000000 IP 10.1.3.1.49153 > 10.1.4.3.9: UDP, length 1024
3.001536 Acknowledgment RA:00:00:00:00:00:00
3.014486 IP 10.1.4.3.9 > 10.1.3.1.49153: UDP, length 1024

fy@ubuntu:~/tarballs/ns-3-allinone/ns-3.30$ tcpdump -nn -tt -r lab3-8-0.pcap
reading from file lab3-8-0.pcap, link-type IEEE802.11 (802.11)
0.036392 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.120000 Assoc Request (WLAN-SSID-2) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.120414 Acknowledgment RA:00:00:00:00:00:00
0.120593 Assoc Request (WLAN-SSID-2) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.120653 Acknowledgment RA:00:00:00:00:00:00
0.120825 Assoc Response AID(1) :: Successful
0.120841 Acknowledgment RA:00:00:00:00:00:00
0.121073 Assoc Request (WLAN-SSID-2) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.121295 Assoc Response AID(2) :: Successful
0.121355 Acknowledgment RA:00:00:00:00:00:00
0.121813 Assoc Request (WLAN-SSID-2) [6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0 Mbit] ESS
0.122188 Assoc Response AID(3) :: Successful
0.122188 Acknowledgment RA:00:00:00:00:00:00
0.122168 Acknowledgment RA:00:00:00:00:00:00
0.138792 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.241192 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.343592 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.445992 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.548392 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.650792 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.753192 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.855592 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
0.957992 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.060392 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.162792 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.265192 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.367592 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.469992 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.572392 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.674792 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.777192 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.879592 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
1.981992 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.020584 ARP, Request who-has 10.1.4.3 (ff:ff:ff:ff:ff:ff) tell 10.1.4.4, length 32
2.020735 ARP, Reply 10.1.4.3 is-at 00:00:00:00:00:00, length 32
2.020907 Acknowledgment RA:00:00:00:00:00:00
2.022498 IP 10.1.3.1.49153 > 10.1.4.3.9: UDP, length 1024
2.022514 Acknowledgment RA:00:00:00:00:00:00
2.027498 ARP, Request who-has 10.1.4.4 (ff:ff:ff:ff:ff:ff) tell 10.1.4.3, length 32
2.027671 Acknowledgment RA:00:00:00:00:00:00
2.027932 ARP, Request who-has 10.1.4.4 (ff:ff:ff:ff:ff:ff) tell 10.1.4.3, length 32
2.028143 ARP, Reply 10.1.4.4 is-at 00:00:00:00:00:00, length 32
2.028159 Acknowledgment RA:00:00:00:00:00:00
2.028264 IP 10.1.4.3.9 > 10.1.3.1.49153: UDP, length 1024
2.029800 Acknowledgment RA:00:00:00:00:00:00
2.084392 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.186792 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.289192 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.391592 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.493992 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.596392 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.698792 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.801192 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
2.903592 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
3.007120 IP 10.1.3.1.49153 > 10.1.4.3.9: UDP, length 1024
3.007136 Acknowledgment RA:00:00:00:00:00:00
3.007313 Beacon (WLAN-SSID-2) [6.0* 9.0 12.0* 18.0 24.0* 36.0 48.0 54.0 Mbit] ESS
3.007365 IP 10.1.4.3.9 > 10.1.3.1.49153: UDP, length 1024
```

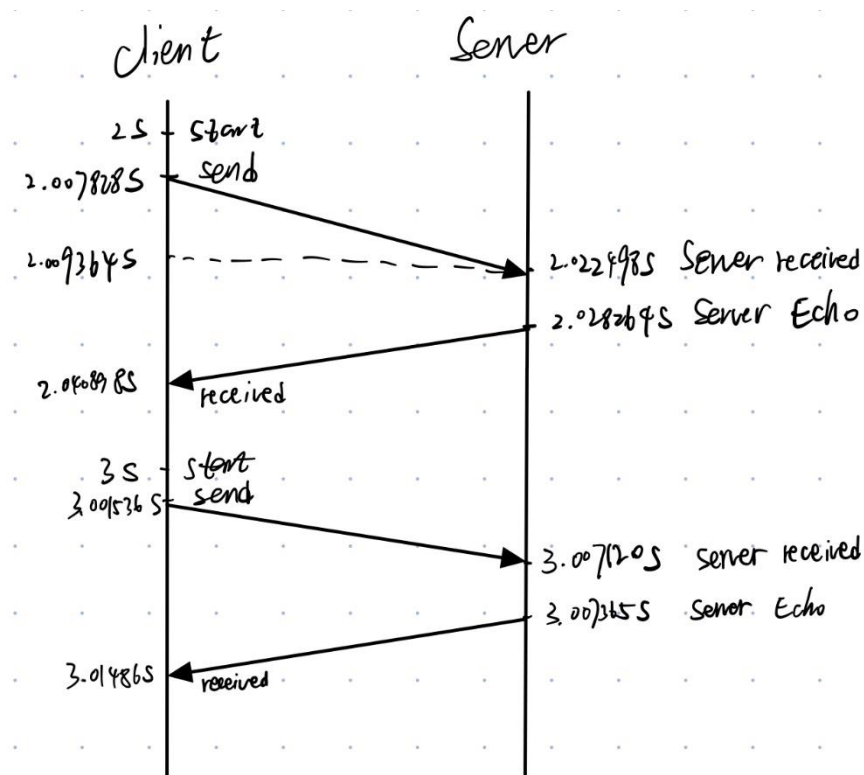
在 UDP 数据包中也有很多 Beacon 帧, 查阅知道是信标帧, 是 AP 间隔发出的信号, 以表达外界无线网络的存在。

ARP 帧对应 IP 地址的物理地址。

4) Brief analysis of the traces

Client (10.1.3.1:49153) 在 2s 和 3s 分别给 Server (10.1.4.3:9) 发送 1024

长度的 UDP 报文，Server 收到之后返回给 Client。大概的流程如下：



三、 实验思考：

关于第一次 2s 发送时间不一的情况：

第一次需要进行 ARP 请求，而这个时间由于硬件不同，可能导致速度不一样，而在第二次发送时候不需要 ARP 请求，故第二次发送时都一样。

关于日志时间和接收方 pcap 计时相异的问题：

第一个包从 n0 发出到 n2 收到需要时间，但是在 pcap 里面发送和接收方的 time 都是零，存在绝对时间之差。而 n2 节点（接收方）pcap 和日志的差值与之一致。即 pcap 是以所在节点收到第一个包开始计时，而 logging 是以虚拟的系统时间来计时。