

Lab 1-1

NS-3 3.26 in Ubuntu 16.04 安裝設定成功，截圖如下：

步驟三

```
schemer@MSI: ~/ns-allinone-3.26/ns-3.26
Build commands will be stored in build/compile_commands.json
'build' finished successfully (3m45.160s)

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

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

Leaving directory `./ns-3.26'
schemer@MSI:~/ns-allinone-3.26$ ls
```

步驟四

```
'configure' finished successfully (4.685s)
schemer@MSI:~/ns-allinone-3.26/ns-3.26$ ./waf
Waf: Entering directory `/home/schemer/ns-allinone-3.26/ns-3.26/build'
Waf: Leaving directory `/home/schemer/ns-allinone-3.26/ns-3.26/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (1.820s)
```

Modules built:

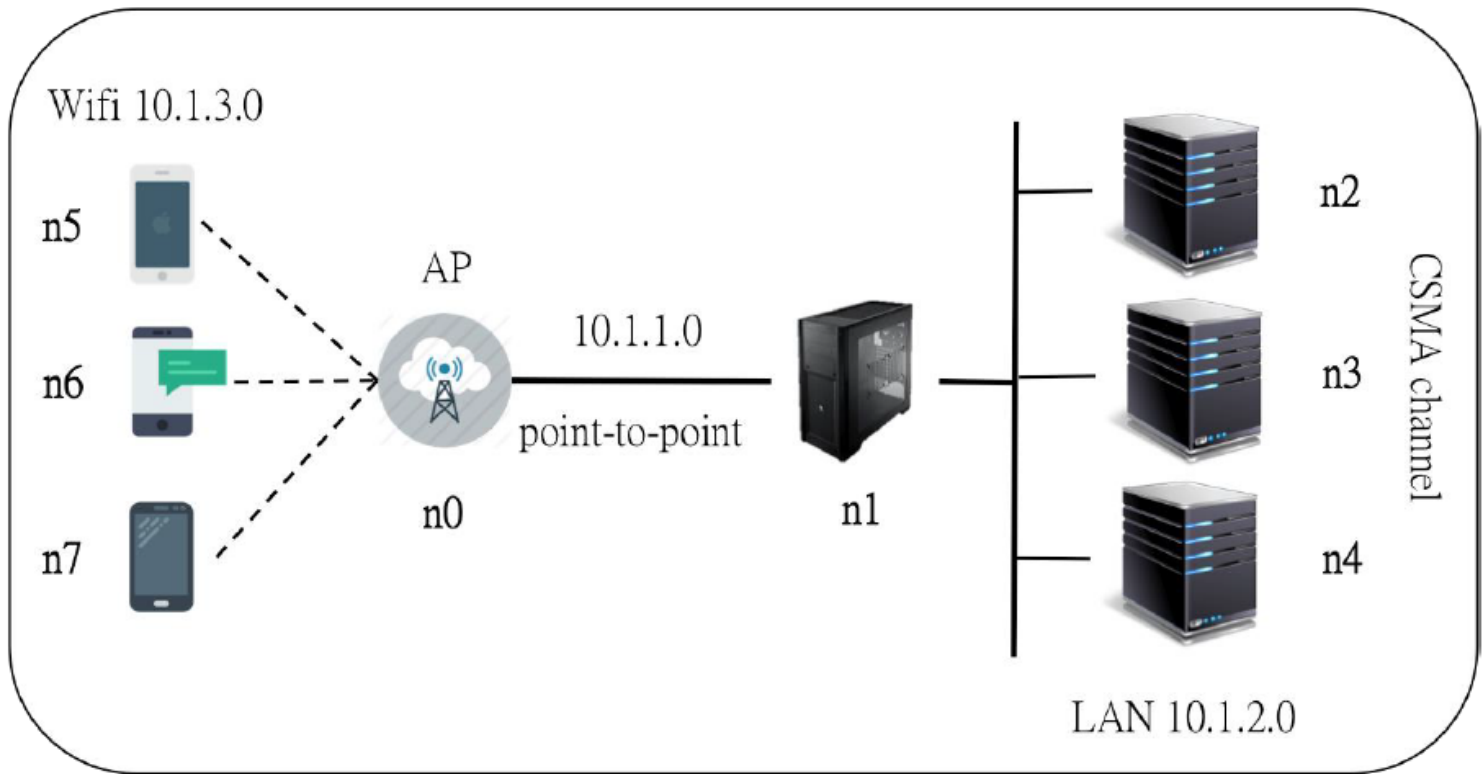
antenna	aodv	applications
bridge	buildings	config-store
core	csma	csma-layout
dsdv	dsr	energy
fd-net-device	flow-monitor	internet
internet-apps	lr-wpan	lte
mesh	mobility	mpi
netanim (no Python)	network	nix-vector-routing
olsr	point-to-point	point-to-point
-layout	sixlowpan	spectrum
propagation	tap-bridge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

步驟五

```
PASS: TestSuite devices-mesh-flame-regression
PASS: TestSuite fq-codel-queue-disc
SKIP: TestSuite ns3-tcp-cwnd
SKIP: TestSuite ns3-tcp-interopability
PASS: TestSuite pfifo-fast-queue-disc
PASS: TestSuite ns3-tcp-no-delay
PASS: TestSuite devices-mesh-dot11s-regression
PASS: TestSuite ns3-tcp-socket
SKIP: TestSuite nsc-tcp-loss
PASS: TestSuite ns3-tcp-state
PASS: TestSuite ns3-wifi-interference
PASS: TestSuite csma-system
PASS: TestSuite ns3-wifi-ac-mapping
PASS: TestSuite traced-callback-typedef
PASS: TestSuite traced-value-callback
PASS: TestSuite adaptive-red-queue-disc
PASS: TestSuite aodv-routing-id-cache
PASS: TestSuite ns3-wifi-msdu-aggregator
PASS: TestSuite pie-queue-disc
PASS: TestSuite ns3-tcp-loss
PASS: TestSuite routing-aodv
PASS: TestSuite routing-aodv-loopback
PASS: TestSuite routing-aodv-regression
PASS: TestSuite lte-test-deactivate-bearer
PASS: TestSuite lte-ue-measurements-piecewise-2
PASS: TestSuite lte-interference-fr
PASS: TestSuite lte-cqi-generation
PASS: TestSuite lte-x2-handover-measures
PASS: TestSuite lte-frequency-reuse
229 of 233 tests passed (229 passed, 3 skipped, 1 failed, 0 crashed, 0 valgrind errors)
List of SKIPped tests:
    ns3-tcp-cwnd
    ns3-tcp-interopability
    nsc-tcp-loss
List of FAILed tests:
    int64x64
```

Lab 1-2

拓撲圖



third.cc script拓撲示意圖



操作結果

執行 third.cc 之後，會產生四個 pcap 檔：

1. third-0-0.pcap
2. third-0-1.pcap
3. third-1-0.pcap
4. third-1-1.pcap

用 Wireshark 開啟後，其說明與截圖如下：

third-0-0.pcap

這是 n0 <-> n1 之間的 echo 連線：

third-0-0.pcap

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.1.3.3	10.1.2.4	UDP	1054	49153 → 9 Len=1024
2	0.018607	10.1.2.4	10.1.3.3	UDP	1054	9 → 49153 Len=1024

▼ Frame 1: 1054 bytes on wire (8432 bits), 1054 bytes captured (8432 bits)

Encapsulation type: PPP (4)

Arrival Time: Jan 1, 1970 08:00:02.008151000 CST
[Time shift for this packet: 0.000000000 seconds]
Epoch Time: 2.008151000 seconds
[Time delta from previous captured frame: 0.000000000 seconds]
[Time delta from previous displayed frame: 0.000000000 seconds]
[Time since reference or first frame: 0.000000000 seconds]
Frame Number: 1
Frame Length: 1054 bytes (8432 bits)
Capture Length: 1054 bytes (8432 bits)
[Frame is marked: False]
[Frame is ignored: False]
[Protocols in frame: ppp:ip:udp:data]
[Coloring Rule Name: UDP]
[Coloring Rule String: udp]

▼ Point-to-Point Protocol

Protocol: Internet Protocol version 4 (0x0021)

▼ Internet Protocol Version 4, Src: 10.1.3.3, Dst: 10.1.2.4

0100 = Version: 4
.... 0101 = Header Length: 20 bytes (5)
► Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 1052
Identification: 0x0000 (0)
► Flags: 0x0000
Time to live: 63
Protocol: UDP (17)
Header checksum: 0x0000 [validation disabled]
[Header checksum status: Unverified]
Source: 10.1.3.3
Destination: 10.1.2.4

▼ User Datagram Protocol Src Port: 49153 Dst Port: 9

0000	00 21 45 00 04 1c 00 00 00 00 3f 11 00 00 0a 01	!E..... ..?
0010	03 03 0a 01 02 04 c0 01 00 09 04 08 00 00 00 00
0020	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

Encapsulation type (frame.encap_type) Packets: 2 · Displayed: 2 (100.0%) Profile: Default

third-0-1.pcap

這是 [n5, n6, n7] <-> n0 之間，n0 做 broadcast，其中一個發訊號找尋其他 WiFi device

第一段

third-0-1.pcap

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	00:00:00_00:00:0a	Broadcast	802.11	61	Beacon frame, SN=0, FN=0, Flags=0....., BI=2304
2	0.000283	00:00:00_00:00:08	00:00:00_00:00:0a	802.11	53	Association Request, SN=0, FN=0, Flags=0.....
3	0.000299	00:00:00_00:00:08	00:00:00_00:00:08 (00:00:00:00:00:08) (RA)	802.11	14	Acknowledgement, Flags=0.....
4	0.000518	00:00:00_00:00:07	00:00:00_00:00:0a	802.11	53	Association Request, SN=0, FN=0, Flags=0.....
5	0.000534	00:00:00_00:00:07	00:00:00_00:00:07 (00:00:00:00:00:07) (RA)	802.11	14	Acknowledgement, Flags=0.....
6	0.000621	00:00:00_00:00:0a	00:00:00_00:00:08	802.11	44	Association Response, SN=1, FN=0, Flags=0.....
7	0.000765	00:00:00_00:00:0a	00:00:00_00:00:0a (00:00:00:00:00:0a) (RA)	802.11	14	Acknowledgement, Flags=0.....
8	0.000931	00:00:00_00:00:09	00:00:00_00:00:0a	802.11	53	Association Request, SN=0, FN=0, Flags=0.....
9	0.000947	00:00:00_00:00:09	00:00:00_00:00:09 (00:00:00:00:00:09) (RA)	802.11	14	Acknowledgement, Flags=0.....
10	0.001070	00:00:00_00:00:0a	00:00:00_00:00:07	802.11	44	Association Response, SN=2, FN=0, Flags=0.....
11	0.001214	00:00:00_00:00:0a	00:00:00_00:00:0a (00:00:00:00:00:0a) (RA)	802.11	14	Acknowledgement, Flags=0.....
12	0.001329	00:00:00_00:00:0a	00:00:00_00:00:09	802.11	44	Association Response, SN=3, FN=0, Flags=0.....
13	0.001473	00:00:00_00:00:0a	00:00:00_00:00:0a (00:00:00:00:00:0a) (RA)	802.11	14	Acknowledgement, Flags=0.....
14	0.102375	00:00:00_00:00:0a	Broadcast	802.11	61	Beacon frame, SN=4, FN=0, Flags=0....., BI=2304
15	0.204775	00:00:00_00:00:0a	Broadcast	802.11	61	Beacon frame, SN=5, FN=0, Flags=0....., BI=2304

Frame 37: 14 bytes on wire (112 bits), 14 bytes captured (112 bits)

IEEE 802.11 Acknowledgement, Flags: 0.....

Type/Subtype: Acknowledgement (0x001d)

Frame Control Field: 0xd480

0000 0000 0000 0000 = Duration: 0 microseconds

Receiver address: 00:00:00_00:00:0a (00:00:00:00:00:0a)

0000 d4 80 00 00 00 00 00 00 00 00 00 00 00 00

Frame (frame), 14 bytes

Packets: 122 · Displayed: 122 (100.0%)

Profile: Default

第二段

third-0-1.pcap

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
32	1.945575	00:00:00_00:00:0a	Broadcast	802.11	61	Beacon frame, SN=22, FN=0, Flags=0....., BI=2304
33	2.006087	00:00:00_00:00:09	Broadcast	ARP	64	Who has 10.1.3.4? Tell 10.1.3.3
34	2.006103	00:00:00_00:00:09	00:00:00_00:00:09 (00:00:00:00:00:09) (RA)	802.11	14	Acknowledgement, Flags=0.....
35	2.006208	00:00:00_00:00:09	Broadcast	ARP	64	Who has 10.1.3.4? Tell 10.1.3.3
36	2.006408	00:00:00_00:00:0a	00:00:00_00:00:09	ARP	64	10.1.3.4 is at 00:00:00:00:00:0a
37	2.006580	00:00:00_00:00:0a	00:00:00_00:00:0a (00:00:00:00:00:0a) (RA)	802.11	14	Acknowledgement, Flags=0.....
38	2.008126	10.1.3.3	10.1.2.4	UDP	1088	49153 → 9 Len=1024
39	2.008142	00:00:00_00:00:09	00:00:00_00:00:09 (00:00:00:00:00:09) (RA)	802.11	14	Acknowledgement, Flags=0.....
40	2.031733	00:00:00_00:00:0a	Broadcast	ARP	64	Who has 10.1.3.3? Tell 10.1.3.4
41	2.031992	00:00:00_00:00:09	00:00:00_00:00:0a	ARP	64	10.1.3.3 is at 00:00:00:00:00:09
42	2.032008	00:00:00_00:00:09	00:00:00_00:00:09 (00:00:00:00:00:09) (RA)	802.11	14	Acknowledgement, Flags=0.....
43	2.032140	10.1.2.4	10.1.3.3	UDP	1088	9 → 49153 Len=1024
44	2.033676	00:00:00_00:00:0a	00:00:00_00:00:0a (00:00:00:00:00:0a) (RA)	802.11	14	Acknowledgement, Flags=0.....
45	2.047975	00:00:00_00:00:0a	Broadcast	802.11	61	Beacon frame, SN=27, FN=0, Flags=0....., BI=2304
46	2.150375	00:00:00_00:00:0a	Broadcast	802.11	61	Beacon frame, SN=28, FN=0, Flags=0....., BI=2304

Frame 33: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)

IEEE 802.11 Data, Flags: 0.....T

Type/Subtype: Data (0x0020)

Frame Control Field: 0x0881

0000 0000 0011 1100 = Duration: 60 microseconds

Receiver address: 00:00:00_00:00:0a (00:00:00:00:00:0a)

Transmitter address: 00:00:00_00:00:09 (00:00:00:00:00:09)

Destination address: Broadcast (ff:ff:ff:ff:ff:ff)

Source address: 00:00:00_00:00:09 (00:00:00:00:00:09)

BSS Id: 00:00:00_00:00:0a (00:00:00:00:00:0a)

STA address: 00:00:00_00:00:09 (00:00:00:00:00:09)

.... 0000 = Fragment number: 0

0000 0000 0001 = Sequence number: 1

Logical-Link Control

DSAP: SNAP (0xaa)

SSAP: SNAP (0xaa)

Control field: U, func=UI (0x03)

Organization Code: 00:00:00 (Officially Xerox, but)

Type: ARP (0x0806)

Address Resolution Protocol (request)

0000 08 81 3c 00 00 00 00 00 00 0a 00 00 00 00 09

Frame (frame), 64 bytes

Packets: 122 · Displayed: 122 (100.0%)

Profile: Default

third-1-0.pcap

在上一動作裡，WiFi 裝置找到彼此後，彼此 echo

third-1-1.pcap

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length Info
1	0.000000	10.1.3.3	10.1.2.4	UDP	1054 → 49153 → 9 Len=1024
2	0.011235	10.1.2.4	10.1.3.3	UDP	1054 → 49153 Len=1024

Frame 1: 1054 bytes on wire (8432 bits), 1054 bytes captured (8432 bits)

Encapsulation type: PPP (4)
Arrival Time: Jan 1, 1970 08:00:02.011837000 CST
[Time shift for this packet: 0.000000000 seconds]
Epoch Time: 2.011837000 seconds
[Time delta from previous captured frame: 0.000000000 seconds]
[Time delta from previous displayed frame: 0.000000000 seconds]
[Time since reference or first frame: 0.000000000 seconds]
Frame Number: 1
Frame Length: 1054 bytes (8432 bits)
Capture Length: 1054 bytes (8432 bits)
[Frame is marked: False]
[Frame is ignored: False]
[Protocols in frame: ppp:ip:udp:data]
[Coloring Rule Name: UDP]
[Coloring Rule String: udp]

Point-to-Point Protocol
Protocol: Internet Protocol version 4 (0x0021)

Internet Protocol Version 4, Src: 10.1.3.3, Dst: 10.1.2.4
0100 = Version: 4
.... 0101 = Header Length: 20 bytes (5)
Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 1052
Identification: 0x0000 (0)
Flags: 0x0000
Time to live: 63
Protocol: UDP (17)
Header checksum: 0x0000 [validation disabled]
[Header checksum status: Unverified]
Source: 10.1.3.3
Destination: 10.1.2.4

User Datagram Protocol, Src Port: 49153, Dst Port: 9
Source Port: 49153
Destination Port: 9

0010 03 03 0a 01 02 04 c0 01 00 09 04 08 00 00 00 00
Data (data), 1024 bytes

Packets: 2 · Displayed: 2 (100.0%) Profile: Default

third-1-1.pcap

這是另一邊，CSMA station 之間互相查找對方的動作

third-1-1.pcap

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length Info
1	0.000000	00:00:00_00:00:03	Broadcast	ARP	64 Who has 10.1.2.4? Tell 10.1.2.1 [ETHERNET FRAME CHECK SEQUENCE INCORRECT]
2	0.000024	00:00:00_00:00:06	00:00:00_00:00:03	ARP	64 10.1.2.4 is at 00:00:00:00:00:06 [ETHERNET FRAME CHECK SEQUENCE INCORRECT]
3	0.000024	10.1.3.3	10.1.2.4	UDP	1070 49153 → 9 Len=1024 [ETHERNET FRAME CHECK SEQUENCE INCORRECT]
4	0.005129	00:00:00_00:00:06	Broadcast	ARP	64 Who has 10.1.2.1? Tell 10.1.2.4 [ETHERNET FRAME CHECK SEQUENCE INCORRECT]
5	0.005129	00:00:00_00:00:03	00:00:00_00:00:06	ARP	64 10.1.2.1 is at 00:00:00:00:00:03 [ETHERNET FRAME CHECK SEQUENCE INCORRECT]
6	0.005235	10.1.2.4	10.1.3.3	UDP	1070 → 49153 Len=1024 [ETHERNET FRAME CHECK SEQUENCE INCORRECT]

Frame 1: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)

Encapsulation type: Ethernet (1)
Arrival Time: Jan 1, 1970 08:00:02.017837000 CST
[Time shift for this packet: 0.000000000 seconds]
Epoch Time: 2.017837000 seconds
[Time delta from previous captured frame: 0.000000000 seconds]
[Time delta from previous displayed frame: 0.000000000 seconds]
[Time since reference or first frame: 0.000000000 seconds]
Frame Number: 1
Frame Length: 64 bytes (512 bits)
Capture Length: 64 bytes (512 bits)
[Frame is marked: False]
[Frame is ignored: False]
[Protocols in frame: eth:ethertype:arp]
[Coloring Rule Name: ARP]
[Coloring Rule String: arp]

Ethernet II, Src: 00:00:00_00:00:03 (00:00:00:00:00:03), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
Destination: Broadcast (ff:ff:ff:ff:ff:ff)
Source: 00:00:00_00:00:03 (00:00:00:00:00:03)
Type: ARP (0x0806)
Padding: 00000000000000000000000000000000
Frame check sequence: 0x00000000 incorrect, should be 0x0b1f2720
[FCS Status: Bad]

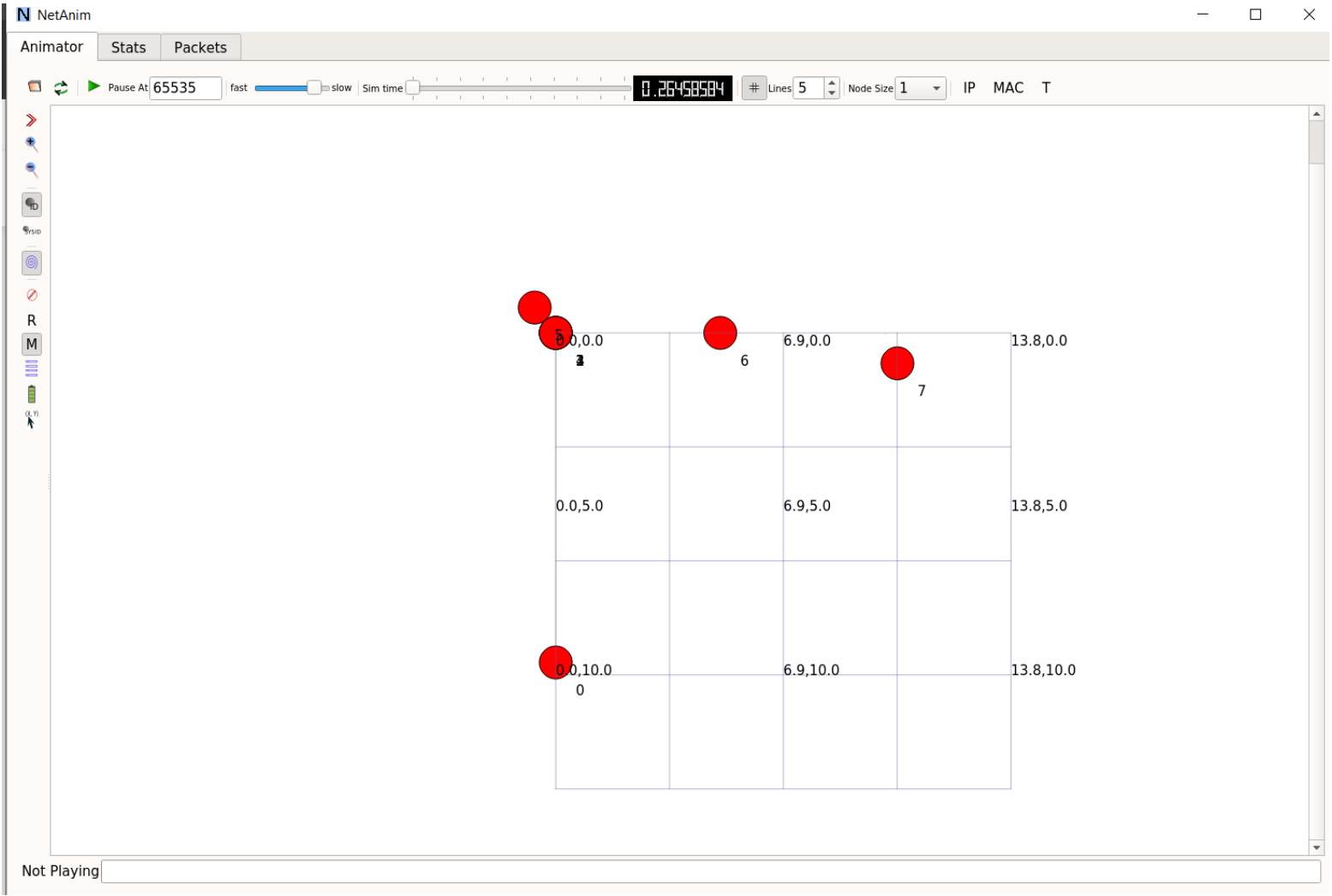
Address Resolution Protocol (request)
Hardware type: Ethernet (1)
Protocol type: IPv4 (0x0800)
Hardware size: 6
Protocol size: 4
Opcode: request (1)
Sender MAC address: 00:00:00_00:00:03 (00:00:00:00:00:03)

0000 ff ff ff ff ff ff 00 00 00 00 03 08 06 00 01
Frame (frame), 64 bytes

Packets: 6 · Displayed: 6 (100.0%) Profile: Default

Lab 1-3

執行 NetAnim 結果如下：



NetAnim

AnimatorStatsPackets

IP-MAC

Sim Time

Font Size 10

FlowMon file

RemainingEnergy

Nodes 0:1:2:3:4:5:6:7:

Show Table

All

None

0

1

2

3

4

5

6

7

Node:0

IP:10.1.1.1

MAC:00:00:00:00:00:01

Other Node:1

Other IP:10.1.1.2

Other MAC:00:00:00:00:00:02

Info:

Node:0

IP:10.1.3.4

MAC:00:00:00:00:00:0a

Node:1

IP:10.1.1.2

MAC:00:00:00:00:00:02

Other Node:0

Other IP:10.1.1.1

Other MAC:00:00:00:00:00:01

Info:

Node:1

IP:10.1.2.1

MAC:00:00:00:00:00:03

Node:2

IP:10.1.2.2

MAC:00:00:00:00:00:04

Node:3

IP:10.1.2.3

MAC:00:00:00:00:00:05

Node:4

IP:10.1.2.4

MAC:00:00:00:00:00:06

Node:5

IP:10.1.3.1

MAC:00:00:00:00:00:07

Node:6

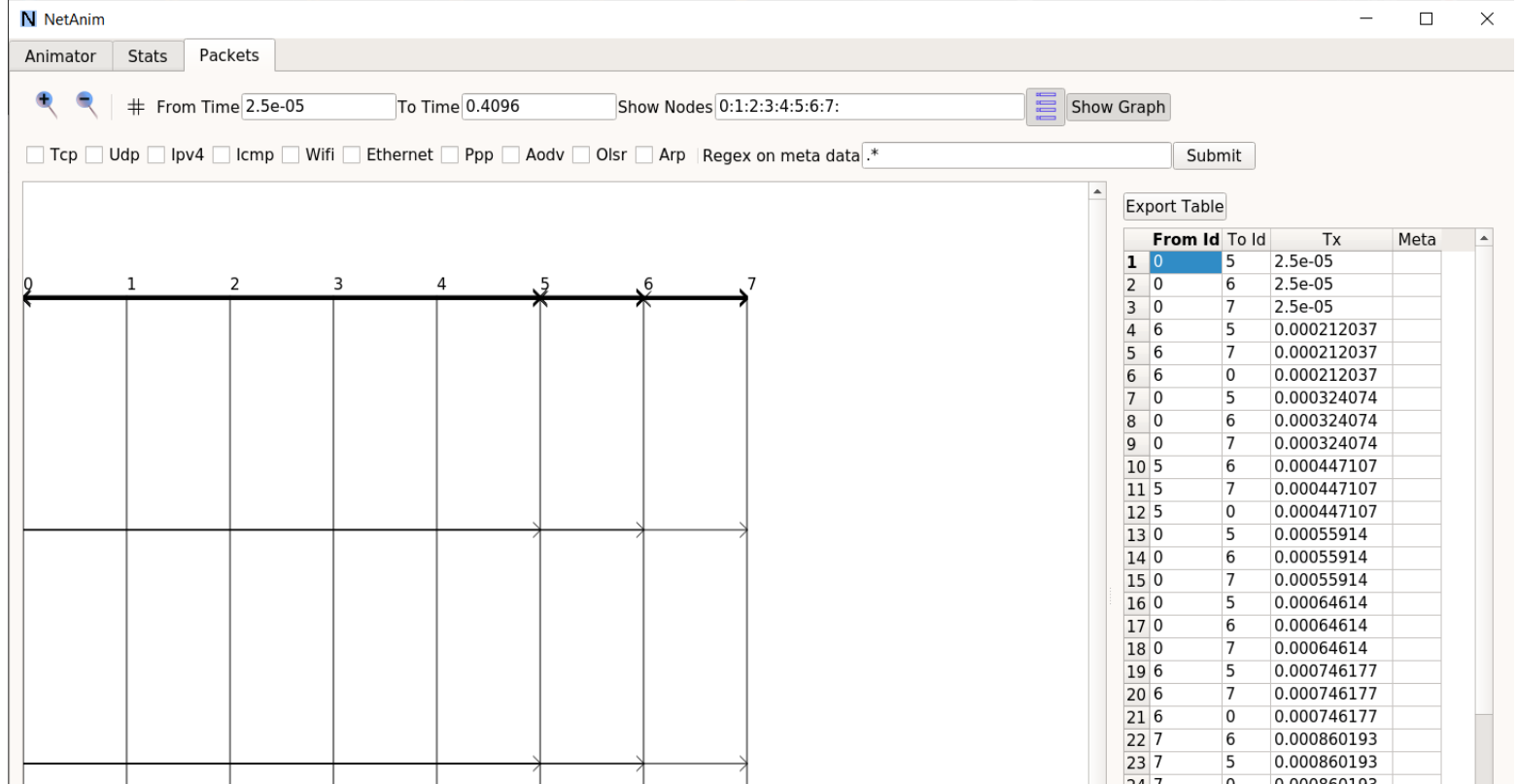
IP:10.1.3.2

MAC:00:00:00:00:00:08

Node:7

IP:10.1.3.3

MAC:00:00:00:00:00:09



Lab 1-4

1. 試根據模擬及 NetAnim 的結果敘述此模擬過程做了哪些事
2. 請問此模擬適合對應 5G 三大服務場景 (URLLC/mMTC/eMBB) 的何者

從以下的這段設定中，可以推測這是 eMBB 的場景

```
// Create the Internet
PointToPointHelper p2ph;
p2ph.SetDeviceAttribute("DataRate", DataRateValue(DataRate("100Gb/s")));
p2ph.SetDeviceAttribute("Mtu", UintegerValue(1500));
p2ph.SetChannelAttribute("Delay", TimeValue(Seconds(0.010)));
```

因

1. data rate 目標為 100Gbps
2. 可容許的 delay (latency) 為 10ms (非 URLLC)
3. 實際執行時，只有 75 個 UE，遠不及 mMTC 的場景

3. 請問此模擬之程式碼中如何增加使用者數量

```
Config::SetDefault("ns3::LteEnbRrc::SrsPeriodicity",
    UintegerValue(320)); // 讓ue可以增加很多
```

4. 試觀察此模擬產生之 txt 檔，敘述模擬可能有的問題，及相對應可能的解決方法