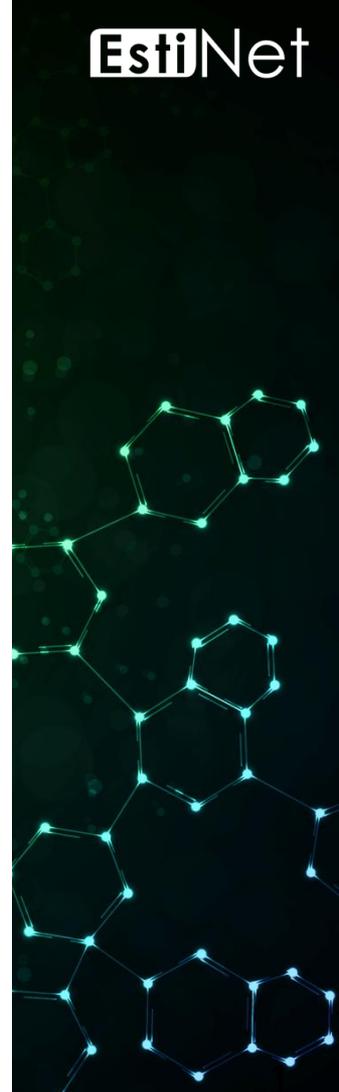


# Simulator Experiment

## Physical Layer



# List of Experiment

- ◆ Calculation of Signal Delivery Time
- ◆ Observation of End-to-end Delay
- ◆ Error Rate of Wired Signal
- ◆ Transmission Range of Wireless Signal

# Simulator Experiment

## Calculation of Signal Delivery Time

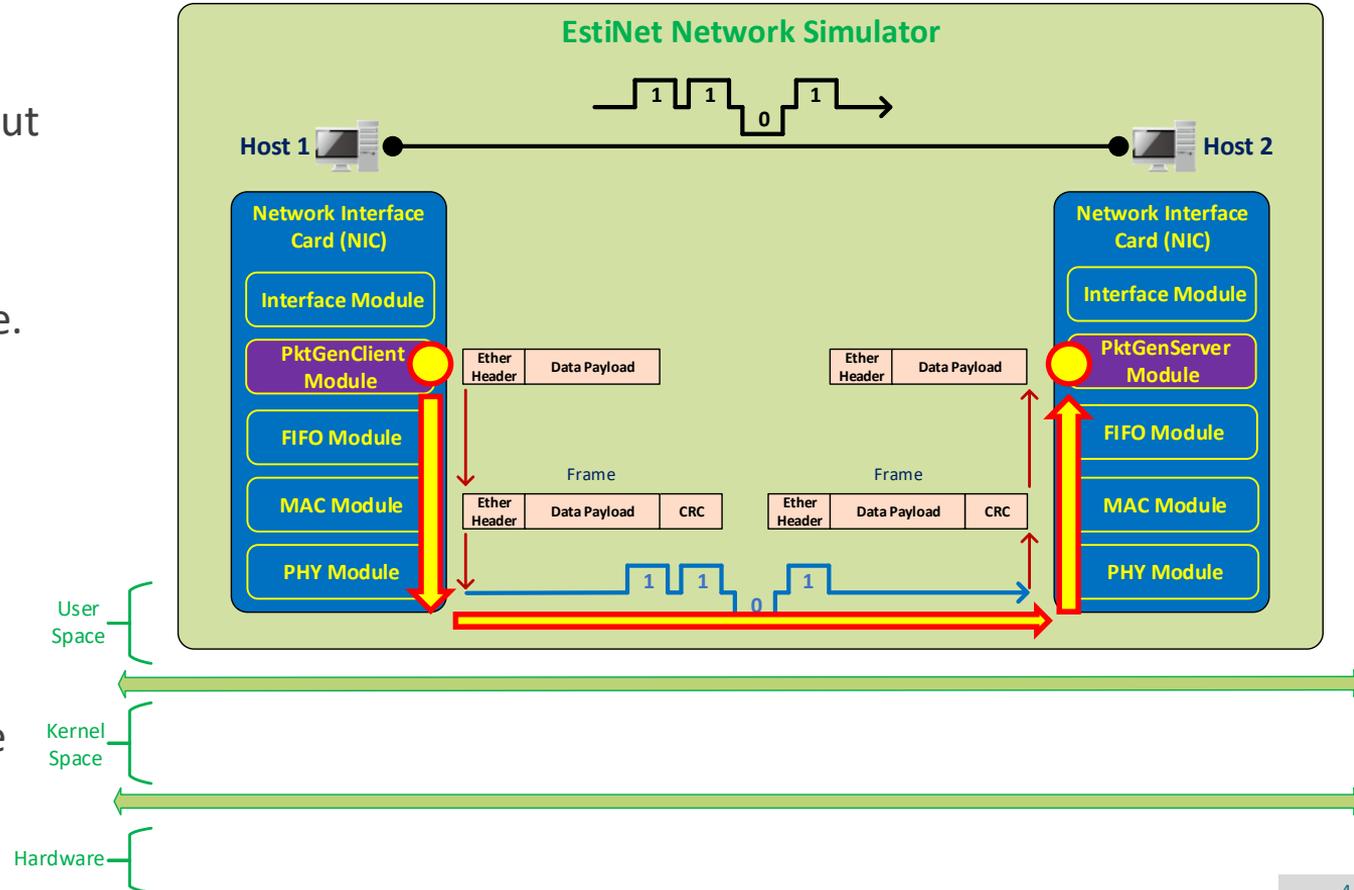
< Simulation Case >

trans\_time\_and\_prop\_delay.xtpl

trans\_time\_and\_prop\_delay\_comparison.xtpl

# The Architecture of Simulation Environment

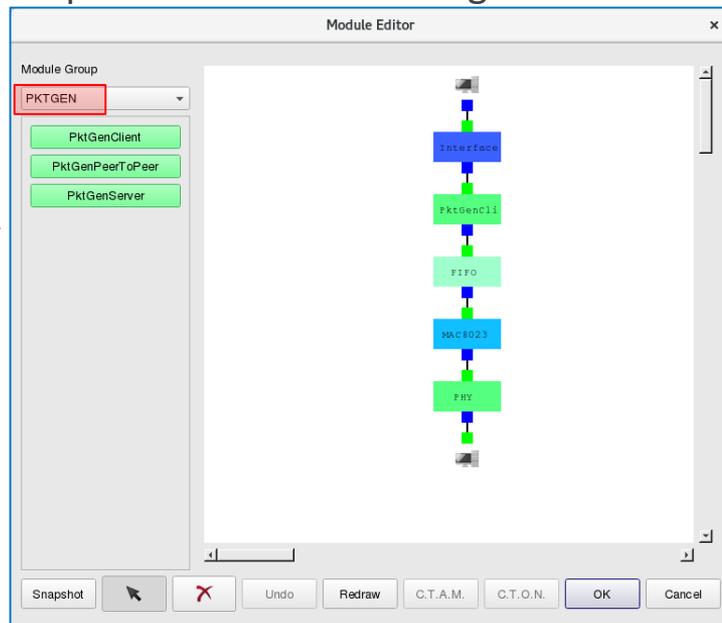
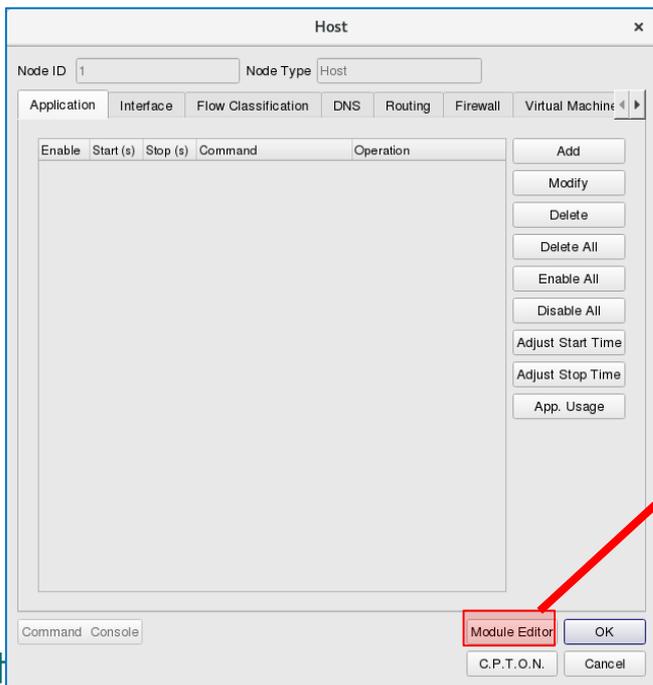
- ◆ On the signal transmitter Host 1, the PktGenClient Module is used to send out a frame. On the signal receiver Host 2, the PktGenServer Module is used to receive the frame.
- ◆ The behavior of transmission time and propagation delay are simulated by the PHY Module at both sites.
- ◆ Note that a FIFO Module has to be inserted below the PktGenClient Module and the PktGenServer Module.



# At Stage E, open the node-editor utility first and then open the module-editor utility to edit protocol stack.

- ◆ At Stage E, double click on any node to open node editor. On the node-editor window, click the Module Editor button to open module editor.

- ◆ On the left side of module-editor window, all available modules are classified by different groups. For example, PktGenServer and PktGenClient modules can be found in the PKTGEN group. Insert required modules into the protocol stack on the right side.



# Configuration of PktGenClient Module

- ◆ Key in the MAC address of receiver Host 2.
- ◆ Key in the length of payload 974 bytes.
- ◆ Key in the length of header 14 bytes.
- ◆ Payload Length + Header Length = 988 bytes
- ◆ Within the MAC8023 module, additional 7-byte Preamble, 1-byte Start Frame Delimiter, and 4-byte CRC Checksum fields will be added into the outgoing frame. Thus, the final length of outgoing frame is 1000 bytes.
- ◆ Limit the total number of outgoing frame to be 1.
- ◆ Set the sending time of the outgoing frame to be 10,000,000 us.

PktGenClient

Parameters Setting

Destination Node MAC Address

Payload Length  (bytes)

Header Length  (bytes)

Limited Number of Output Packet

Total Number of Output Packet

Packet Generation Mode

Fixed Interval

Fixed Generation Interval  (us)

Random Interval

Maximum Random Generation Interval  (us)

Exponential Interval

Mean Payload Sending Rate  (bytes/us)

Ping Pong

Fixed Interval and Ping Pong

Fixed Generation Interval  (us)

Random Interval and Ping Pong

Maximum Random Generation Interval  (us)

Exponential Interval and Ping Pong

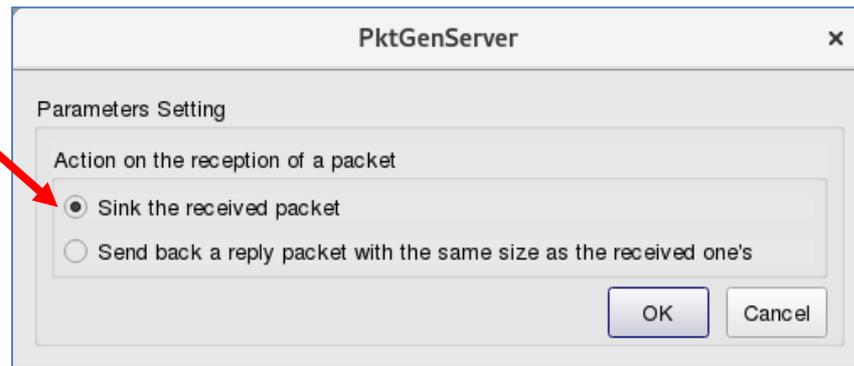
Mean Payload Sending Rate  (bytes/us)

OK

Cancel

# Configuration of PktGenServer Module

- ◆ Once the receiver Host 2 receives a frame, it drops the frame.



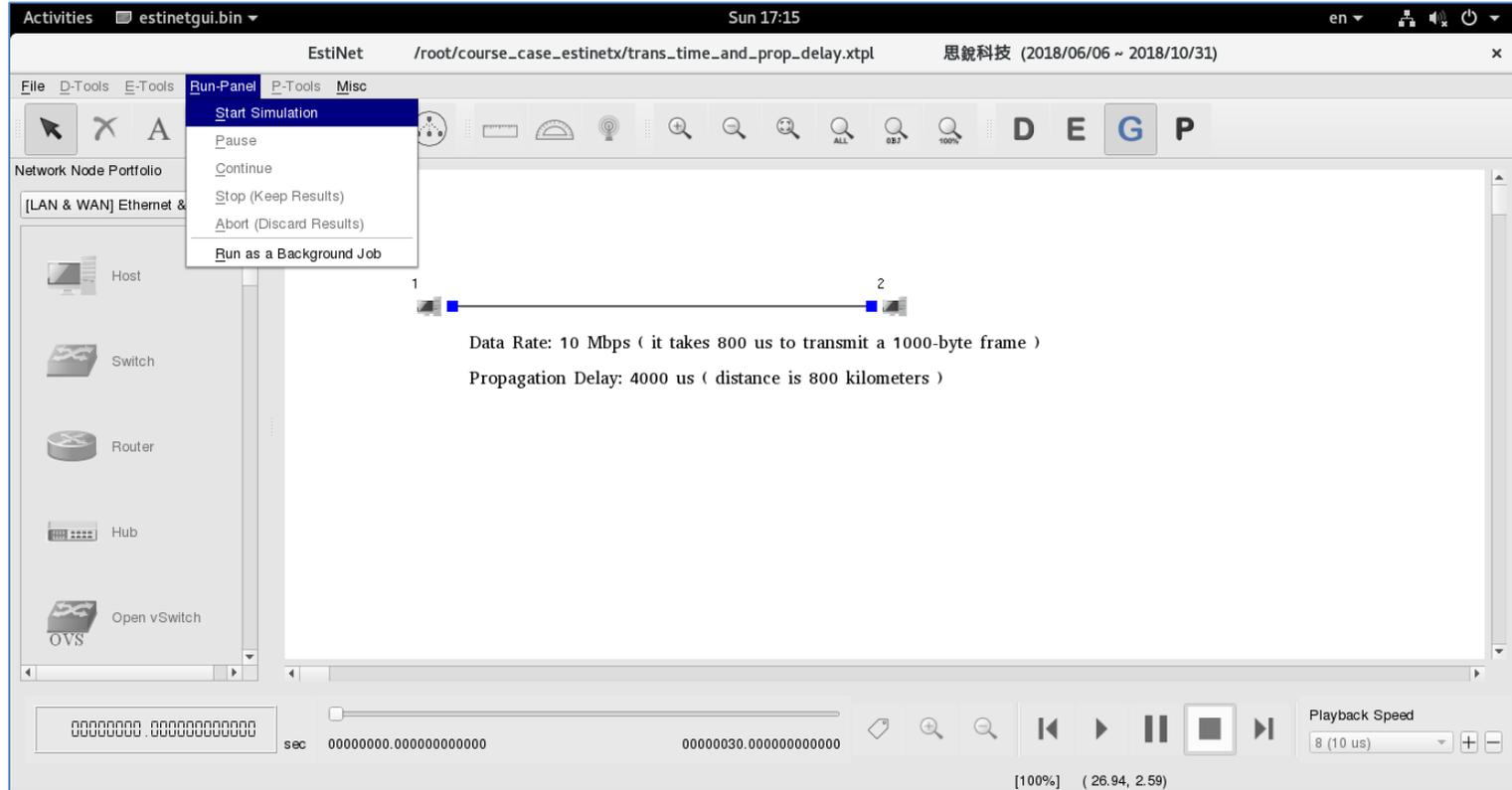
# Configuration of the Link between Host 1 and Host 2

The screenshot shows a window titled "LINK" with a close button (X) in the top right corner. The window is divided into two main sections: "From Node1 to Node2" on the left and "From Node2 to Node1" on the right. Each section contains three rows of configuration options:

- Data Rate:** A dropdown menu set to "10\_Mbps", followed by "C.T.O.D" and "C.T.A.L" buttons.
- Bit Error Rate:** A text input field containing "0.0", followed by "C.T.O.D" and "C.T.A.L" buttons.
- Propagation Delay:** A text input field containing "4000", followed by "(us)", "C.T.O.D", and "C.T.A.L" buttons.

- ◆ Data Rate = 10 Mbps  
Transmission time of a 1000-byte frame =  $(8 * 1000) / (10 * 10^6) = 0.0008$  sec
- ◆ Propagation Delay = 4000 us = 0.004 sec  
Distance =  $0.004 * (2 * 10^8) = 800000$  meters = 800 kilometers

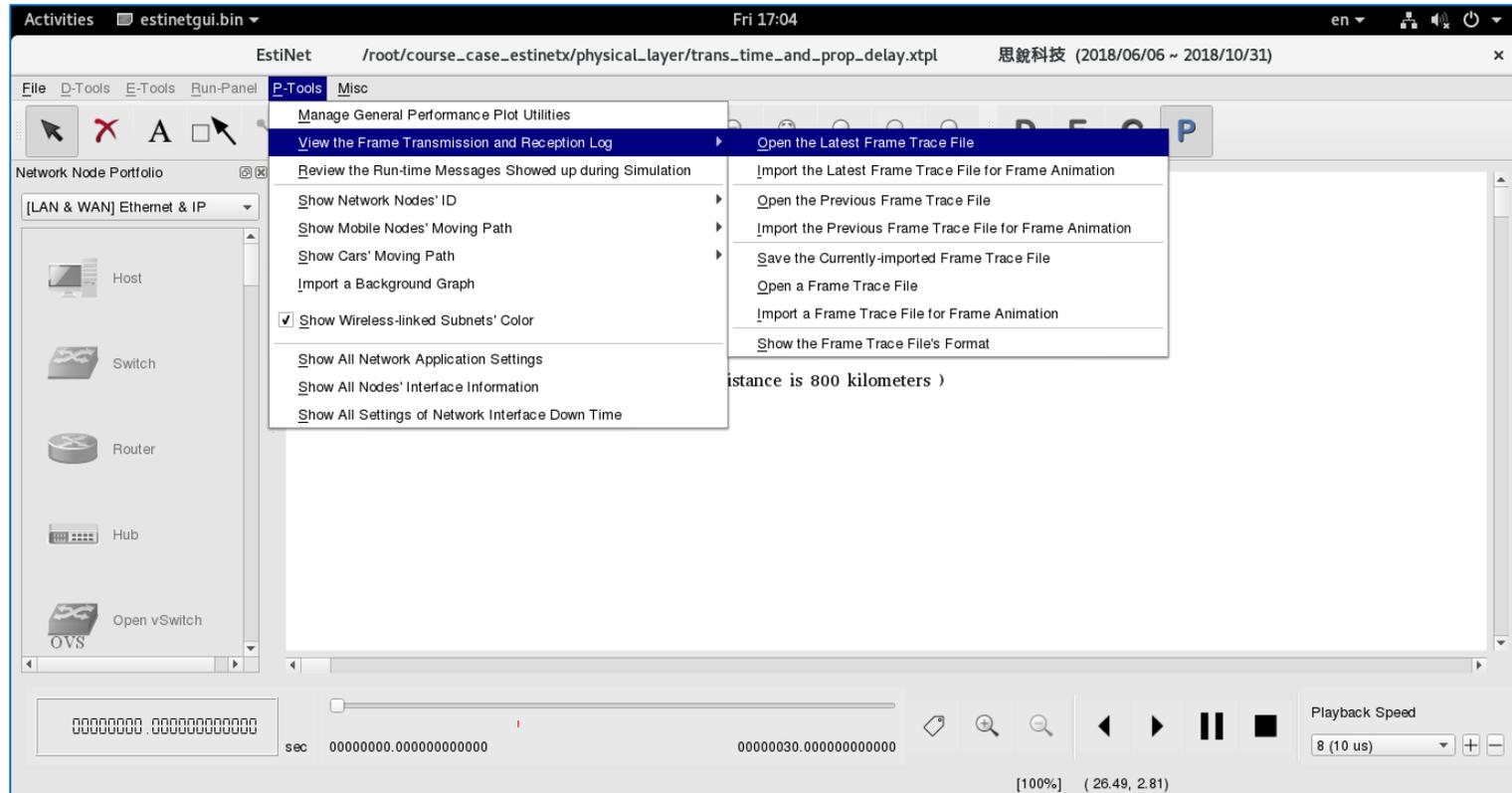
# Change the operating stage to Stage G to generate all simulation configuration files. Then start simulation.



# When simulation is done, check simulation results at Stage P.

The screenshot displays the EstiNet GUI interface. The window title is "EstiNet /root/course\_case\_estinetx/trans\_time\_and\_prop\_delay.xtpl" with a subtitle "思銳科技 (2018/06/06 ~ 2018/10/31)". The top menu bar includes "File", "D-Tools", "E-Tools", "Run-Panel", "P-Tools", and "Misc". The toolbar contains various icons for navigation and simulation control, with a "P" button highlighted. On the left, the "Network Node Portfolio" is visible, listing "Host", "Switch", "Router", "Hub", and "Open vSwitch". The main workspace shows a simulation diagram with two nodes, labeled "1" and "2", connected by a horizontal line. A red arrow labeled "FRAME" points from node 1 to node 2. Below the diagram, the following text is displayed: "Data Rate: 10 Mbps ( it takes 800 us to transmit a 1000-byte frame )" and "Propagation Delay: 4000 us ( distance is 800 kilometers )". At the bottom, there is a timeline with a play button, a "Playback Speed" dropdown set to "8 (10 us)", and a status bar showing "[100%] ( 30.77, 2.70)".

# At Stage P, open the frame trace file to check the logs of frame transmission and reception.



A frame's transmission time and propagation delay can be observed in the frame trace file. The signal/frame delivery time is the sum of both.

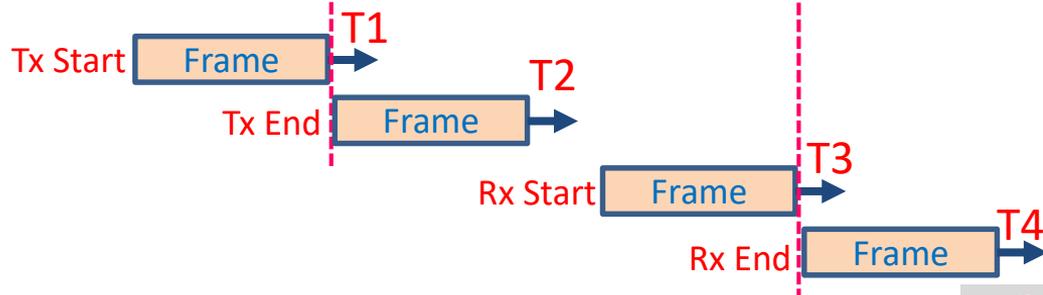
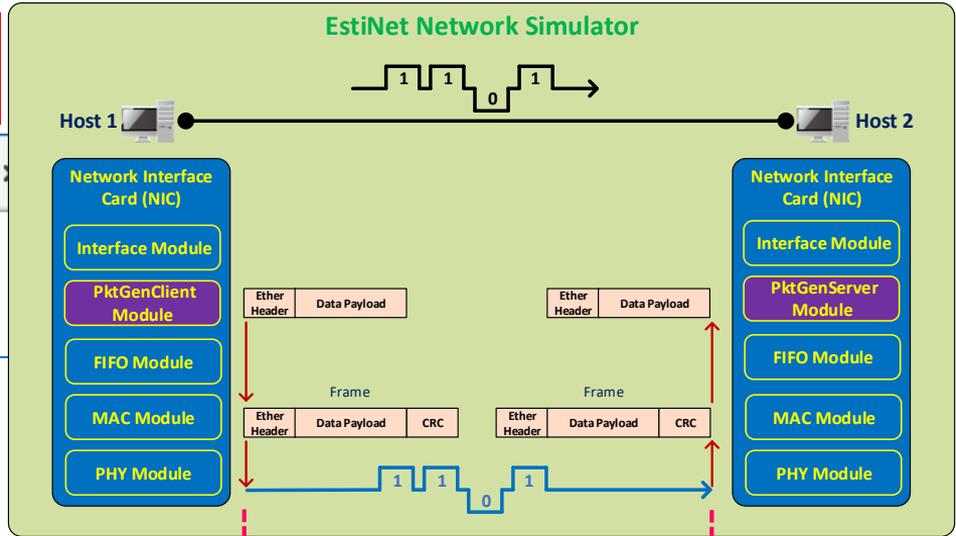
event last period

event start time

time unit is picosecond, that is  $10^{-12}$  second

```
less
802.3 TX 10000000000000 800000000 DATA <0 0> <1 2> 18 1000 0 NONE 0
802.3 RX 100040000000000 800000000 DATA <0 0> <1 2> 18 1000 0 NONE 0
/tmp/frame_trace_file.log (END)
```

- ◆  $T1 = 10,000,000,000,000 * 10^{-12} = 10 \text{ sec}$
- ◆  $T2 - T1 = 800,000,000 * 10^{-12} = 0.0008 \text{ sec}$
- Transmission Time = 0.0008 sec
- ◆  $T3 = 10,004,000,000,000 * 10^{-12}$   
= 10.004 sec
- ◆  $T3 - T1 = 0.004 \text{ sec}$
- ◆ Propagation Delay = 0.004 sec



# Quiz

- ◆ Use simulator to change a frame's transmission time or propagation delay. See what is the difference between the following two conditions.
  - ▣ Transmission Time > Propagation Delay
  - ▣ Transmission Time < Propagation Delay

The screenshot shows the EstiNet simulator interface. The main window displays a network topology with two links. The top link, labeled 1 and 2, has a data rate of 10 Mbps and a propagation delay of 1600 us (distance is 320 kilometers). The bottom link, labeled 3 and 4, has a data rate of 10 Mbps and a propagation delay of 400 us (distance is 80 meters). The interface includes a menu bar (File, D-Tools, E-Tools, Run-Panel, P-Tools, Misc), a toolbar with various icons, and a Network Node Portfolio on the left side. The playback control bar at the bottom shows a time scale in seconds and a playback speed of 8 (10 us).

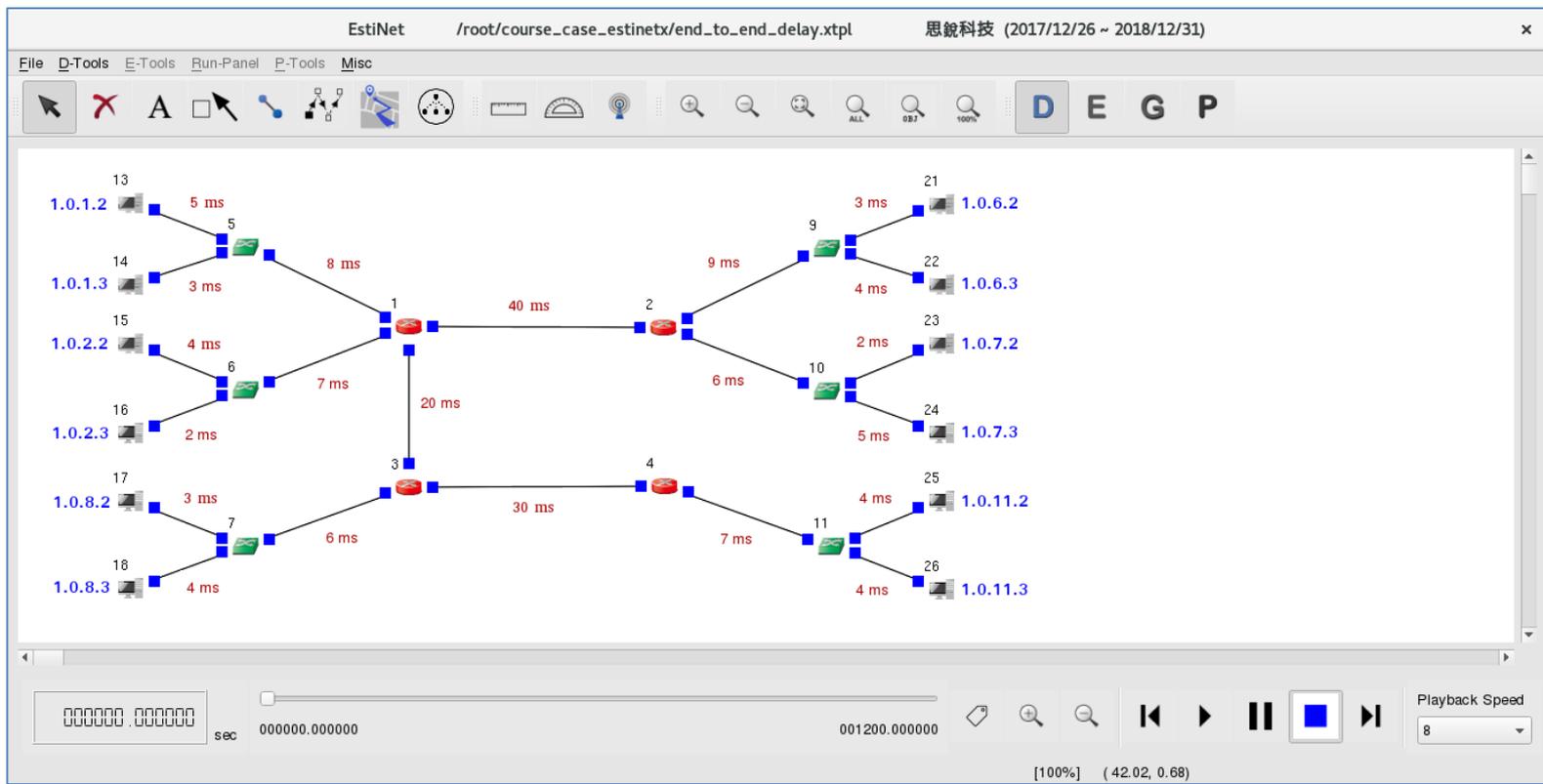
# Simulator Experiment Observation of End-to-end Delay

< Simulation Case >

end\_to\_end\_delay.xtpl

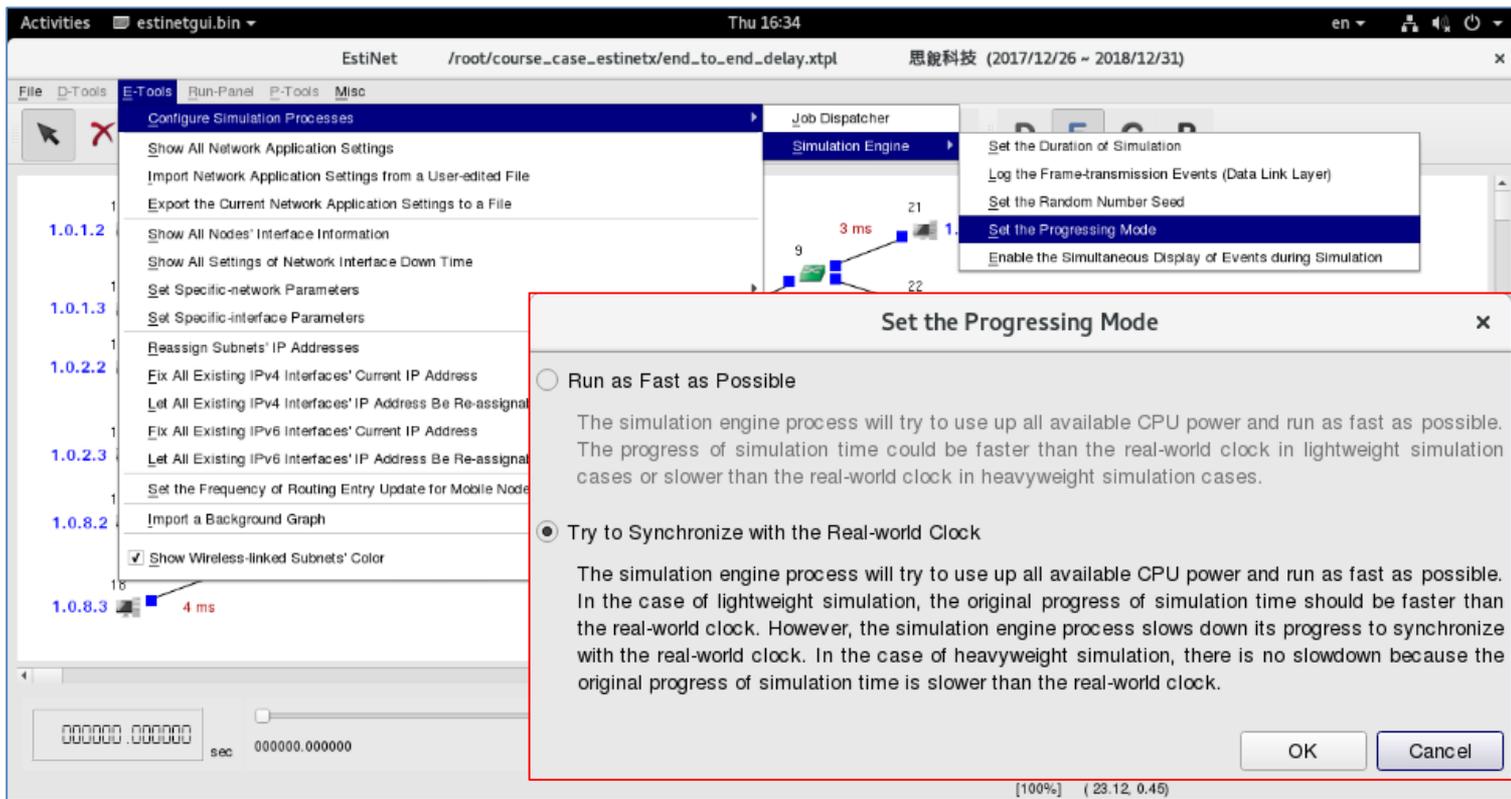
end\_to\_end\_delay\_trans\_time\_dominates.xtpl

Build a network at Stage D. Set each link's propagation delay at Stage E. When running simulation at Stage G, execute the ping command to observe end-to-end delays.



# At Stage E, set the Progressing Mode to “Try to Synchronize with the Real-world Clock”.

Doing this setting is for slowing down the progress speed of virtual time during simulation so that a user is able to interact with the simulated network.



# Change the operating stage to Stage G to generate all simulation configuration files. Then start simulation.

The screenshot displays the EstiNet software interface. The main window shows a network topology with nodes 1 through 26. Node 1 is highlighted with a red circle. A context menu is open over node 1, showing the following options:

- Start Simulation
- Pause
- Continue
- Stop (Keep Results)
- Abort (Discard Results)
- Run as a Background Job

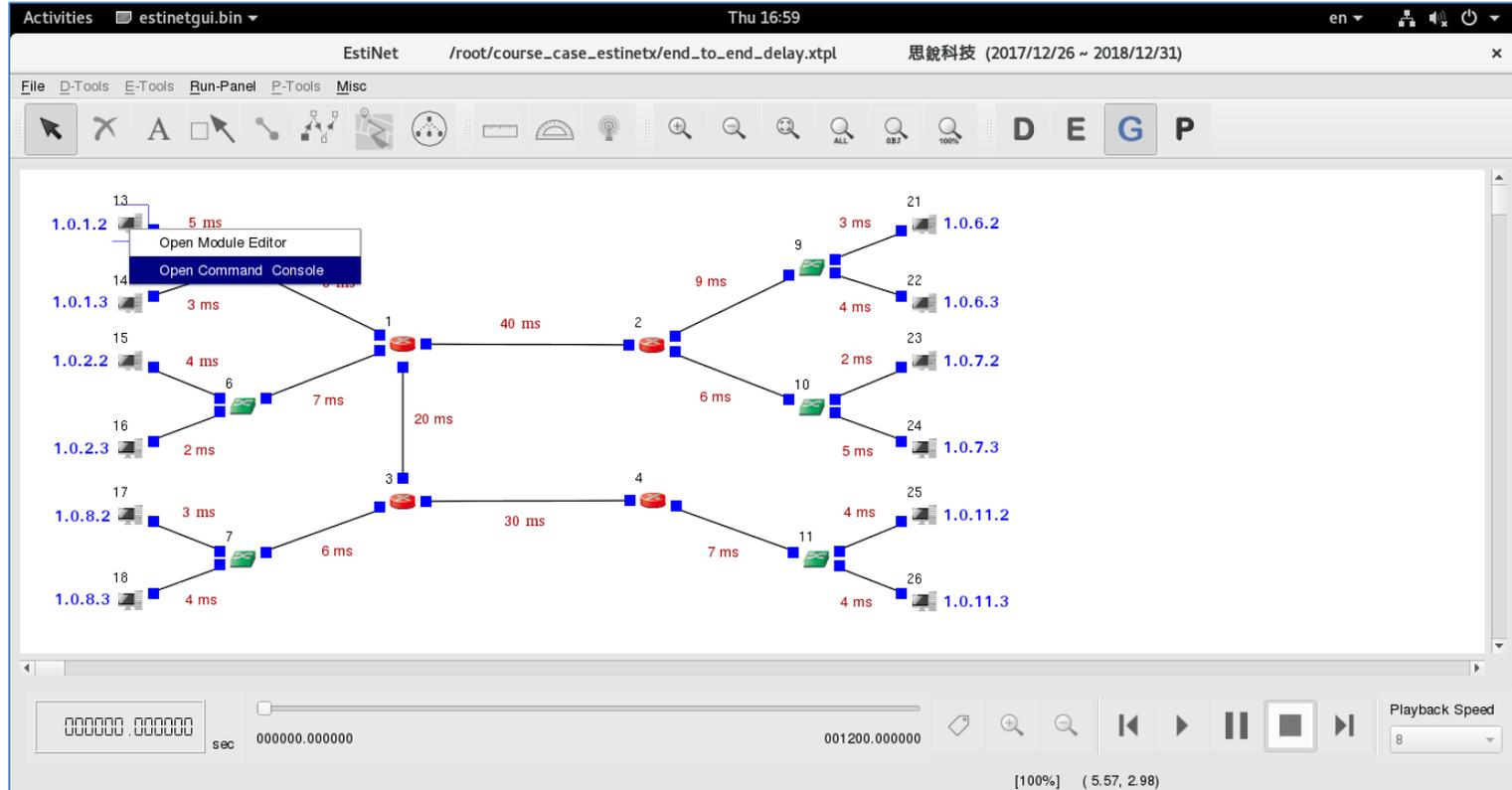
The network diagram includes the following nodes and their IP addresses:

- Node 1: 1.0.1.2
- Node 2: 1.0.6.2
- Node 3: 1.0.8.2
- Node 4: 1.0.11.2
- Node 5: 1.0.1.3
- Node 6: 1.0.2.2
- Node 7: 1.0.2.3
- Node 8: 1.0.8.3
- Node 9: 1.0.6.3
- Node 10: 1.0.7.2
- Node 11: 1.0.7.3
- Node 12: 1.0.1.3
- Node 13: 1.0.1.2
- Node 14: 1.0.1.3
- Node 15: 1.0.2.2
- Node 16: 1.0.2.3
- Node 17: 1.0.8.2
- Node 18: 1.0.8.3
- Node 19: 1.0.6.2
- Node 20: 1.0.6.3
- Node 21: 1.0.7.2
- Node 22: 1.0.7.3
- Node 23: 1.0.11.2
- Node 24: 1.0.11.3
- Node 25: 1.0.11.2
- Node 26: 1.0.11.3

The status bar at the bottom shows the following information:

- Time: 000000.000000 sec
- Playback Speed: 9 (100 us)
- Zoom: [100%]
- Coordinates: (27.23, 0.96)

# During simulation, right click on any Host Node to open a command console.



# On the command console window, use ping command to observe the Round Trip Time (RTT) between any pair of Host Nodes.

1000-byte frame over a 10-Mbps link  
Transmission Time = 0.8 ms

$(5+8+20+6+4)*2 + (0.8*5)*2 = 94$

```
[root@localhost node13]# ping -s 946 1.0.8.3
PING 1.0.8.3 (1.0.8.3) 946(974) bytes of data.
 954 bytes from 1.0.8.3: icmp_seq=1 ttl=62 time=181 ms
 954 bytes from 1.0.8.3: icmp_seq=2 ttl=62 time=94.0 ms
 954 bytes from 1.0.8.3: icmp_seq=3 ttl=62 time=94.0 ms
 954 bytes from 1.0.8.3: icmp_seq=4 ttl=62 time=94.0 ms
 954 bytes from 1.0.8.3: icmp_seq=5 ttl=62 time=94.0 ms
^C
--- 1.0.8.3 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4006ms
rtt min/avg/max/mdev = 94.000/111.515/181.576/35.031 ms
[root@localhost node13]# ping -s 946 1.0.7.3
PING 1.0.7.3 (1.0.7.3) 946(974) bytes of data.
 954 bytes from 1.0.7.3: icmp_seq=1 ttl=62 time=238 ms
 954 bytes from 1.0.7.3: icmp_seq=2 ttl=62 time=136 ms
 954 bytes from 1.0.7.3: icmp_seq=3 ttl=62 time=136 ms
 954 bytes from 1.0.7.3: icmp_seq=4 ttl=62 time=136 ms
 954 bytes from 1.0.7.3: icmp_seq=5 ttl=62 time=136 ms
^C
--- 1.0.7.3 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4005ms
rtt min/avg/max/mdev = 136.000/156.469/238.345/40.938 ms
[root@localhost node13]#
```

$(5+8+40+6+5)*2 + (0.8*5)*2 = 136$

# Quiz

- ◆ In terms of end-to-end delay, if the processing delay on network devices are ignored, observe and discuss the following two conditions.
  - ❑ Transmission Time >> Propagation Delay
  - ❑ Transmission Time << Propagation Delay

The screenshot shows a network simulation in EstiNet. The network topology consists of 13 nodes. Nodes 1, 2, 3, and 4 are core nodes, while nodes 5-13 are edge nodes. Links between nodes are labeled with propagation delays: 1 us for most links, 40 us for the link between nodes 1 and 2, 20 us for the link between nodes 1 and 3, and 30 us for the link between nodes 3 and 4. A text box in the top right corner states: "1000-byte frame over a 10-Mbps link Transmission Time = 0.8 ms".

On the right side, a terminal window shows ping results for Node 13:

```

NODE 13
[root@localhost node13]# ping -s 946 1.0.1.3
PING 1.0.1.3 (1.0.1.3) 946(974) bytes of data:
954 bytes from 1.0.1.3: icmp_seq=1 ttl=64 time=3.20 ms
954 bytes from 1.0.1.3: icmp_seq=2 ttl=64 time=3.20 ms
^C
--- 1.0.1.3 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 3.204/3.204/3.204/0.000 ms
[root@localhost node13]# ping -s 946 1.0.2.3
PING 1.0.2.3 (1.0.2.3) 946(974) bytes of data:
954 bytes from 1.0.2.3: icmp_seq=1 ttl=63 time=6.40 ms
954 bytes from 1.0.2.3: icmp_seq=2 ttl=63 time=6.40 ms
^C
--- 1.0.2.3 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 6.408/6.408/6.408/0.000 ms
[root@localhost node13]# ping -s 946 1.0.8.3
PING 1.0.8.3 (1.0.8.3) 946(974) bytes of data:
954 bytes from 1.0.8.3: icmp_seq=1 ttl=62 time=8.04 ms
954 bytes from 1.0.8.3: icmp_seq=2 ttl=62 time=8.04 ms
^C
--- 1.0.8.3 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 8.048/8.048/8.048/0.000 ms
[root@localhost node13]#

```

Handwritten red annotations next to the ping statistics show the calculation of end-to-end delay:

- For 1.0.1.3:  $0.8 * 4 + 0.004 = 3.204$
- For 1.0.2.3:  $0.8 * 8 + 0.008 = 6.408$
- For 1.0.8.3:  $0.8 * 10 + 0.048 = 8.048$

# Simulator Experiment Error Rate of Wired Signal

< Simulation Case >  
bit\_error\_rate.xtpl

# At Stage D, build three independent networks for comparison.

EstiNet /root/course\_case\_estinets/bit\_error\_rate.xtpl 思銳科技 (2017/12/26 ~ 2018/12/31)

File D-Tools E-Tools Run-Panel P-Tools Misc

Network Node Portfolio [LAN & WAN] Ethernet & IP

- Host
- Switch
- Router
- Hub
- Open vSwitch

1 2

Outgoing Frame: 1000 frames per second, each frame's length is 1000 bytes (8000 bits)  
Bit Error Rate: 0.0000125 (approximately 100 dropped every 1000 frames)

3 4

Outgoing Frame: 1000 frames per second, each frame's length is 1000 bytes (8000 bits)  
Bit Error Rate: 0.000025 (approximately 200 dropped every 1000 frames)

5 6

Outgoing Frame: 1000 frames per second, each frame's length is 1000 bytes (8000 bits)  
Bit Error Rate: 0.0000625 (approximately 500 dropped every 1000 frames)

sec 00000000.000000000000 00000030.000000000000

[100%] (35.04, 0.79)

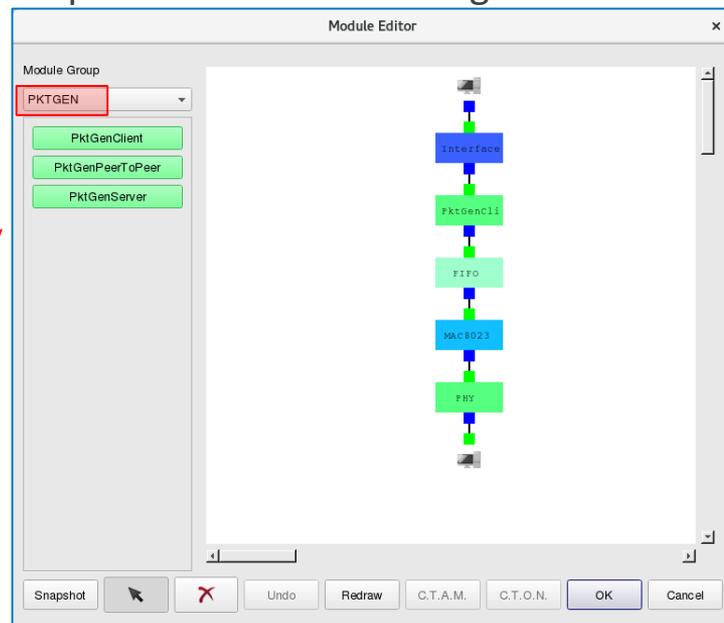
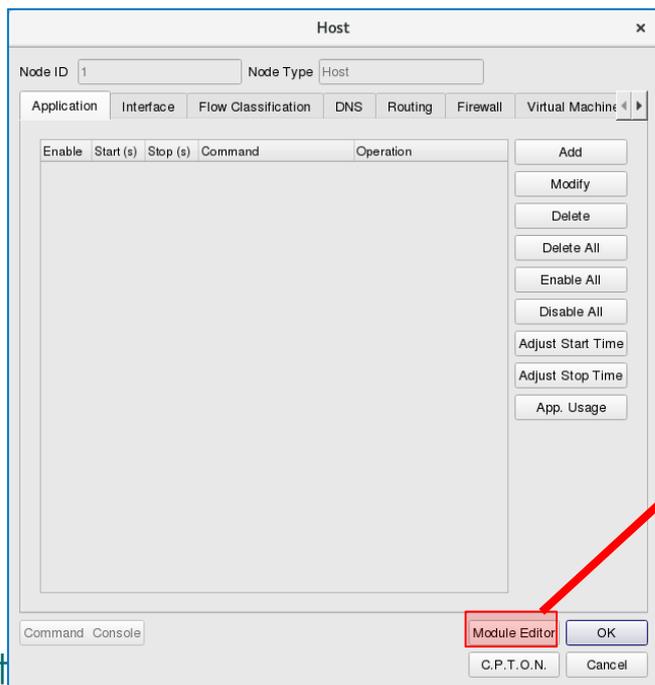
Playback Speed 8



# At Stage E, open the node-editor utility first and then open the module-editor utility to edit protocol stack.

- ◆ At Stage E, double click on any node to open node editor. On the node-editor window, click the Module Editor button to open module editor.

- ◆ On the left side of module-editor window, all available modules are classified by different groups. For example, PktGenServer and PktGenClient modules can be found in the PKTGEN group. Insert required modules into the protocol stack on the right side.



# Configuration of PktGenClient Module

- ◆ Key in the MAC address of receivers Host 2/4/6.
- ◆ Key in the length of payload 974 bytes.
- ◆ Key in the length of header 14 bytes.
- ◆ Payload Length + Header Length = 988 bytes
- ◆ Within the MAC8023 module, additional 7-byte Preamble, 1-byte Start Frame Delimiter, and 4-byte CRC Checksum fields will be added into the outgoing frame. Thus, the final length of outgoing frame is 1000 bytes.
- ◆ When a simulation is started, one frame is sent out every 1000 us. In other words, 1000 frames are sent out every 1 sec.

PktGenClient

Parameters Setting

Destination Node MAC Address

Payload Length  (bytes)

Header Length  (bytes)

Limited Number of Output Packet

Total Number of Output Packet

Packet Generation Mode

Fixed Interval

Fixed Generation Interval  (us)

Random Interval

Maximum Random Generation Interval  (us)

Exponential Interval

Mean Payload Sending Rate  (bytes/us)

Ping Pong

Fixed Interval and Ping Pong

Fixed Generation Interval  (us)

Random Interval and Ping Pong

Maximum Random Generation Interval  (us)

Exponential Interval and Ping Pong

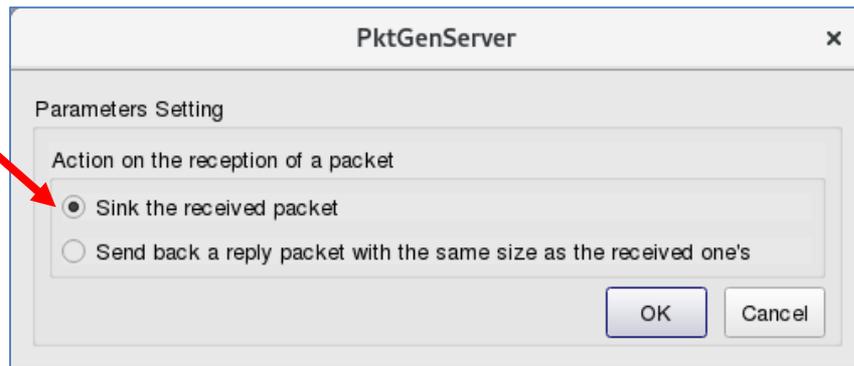
Mean Payload Sending Rate  (bytes/us)

OK

Cancel

# Configuration of PktGenServer Module

- ◆ Once the receivers Host 2/4/6 receive a frame, they drops the frame.



# At Stage E, set different Bit Error Rate for the three links.

- ◆ Set Bit Error Rate to 0.0000125 for the link between Host 1 and Host 2
- ◆ Set Bit Error Rate to 0.000025 for the link between Host 3 and Host 4
- ◆ Set Bit Error Rate to 0.0000625 for the link between Host 5 and Host 6
  
- ◆ Set Propagation Delay to 4000 us for all three links

The screenshot shows a 'LINK' configuration window with two columns for traffic directions: 'From Node1 to Node2' and 'From Node2 to Node1'. Each column has the following settings:

- Data Rate: 10\_Mbps (dropdown menu)
- Bit Error Rate: 0.0000125 (text input)
- Propagation Delay: 4000 (us) (text input)
- Interface ID: 1 (text input)
- Name: eth0 (text input)
- Type: 8023 (text input)

Below these settings is an 'Interface Down Time' section with a table for scheduling:

Start (s)	End (s)	Buttons
		Add, Delete, C.T.O.I.

At the bottom right of the window are 'OK' and 'Cancel' buttons.

# Before simulation, evaluate the frame error rate according to the bit error rate.

- ◆ If the length of a frame is 1000 bytes (8000 bits), and the bit error rate is  $1/80000$  (0.0000125), that means, there is one bit error every 80000 bits. In other words, there is one frame with a bit error every 10 frames. Thus, the frame error rate is  $1/10$  (0.1).
  - ▣ Bit Error Rate = 0.0000125 ( $1/80000$ ) → Frame Error Rate = 0.1 (10%)
  - ▣ Bit Error Rate = 0.000025 ( $1/40000$ ) → Frame Error Rate = 0.2 (20%)
  - ▣ Bit Error Rate = 0.0000625 ( $1/16000$ ) → Frame Error Rate = 0.5 (50%)
- ◆ Consider that each sender sends out 1000 frames every second:
  - ▣ Frame Error Rate = 10% → On the receiver, about 100 frames with error and 900 frames received successfully
  - ▣ Frame Error Rate = 20% → On the receiver, about 200 frames with error and 800 frames received successfully
  - ▣ Frame Error Rate = 50% → On the receiver, about 500 frames with error and 500 frames received successfully

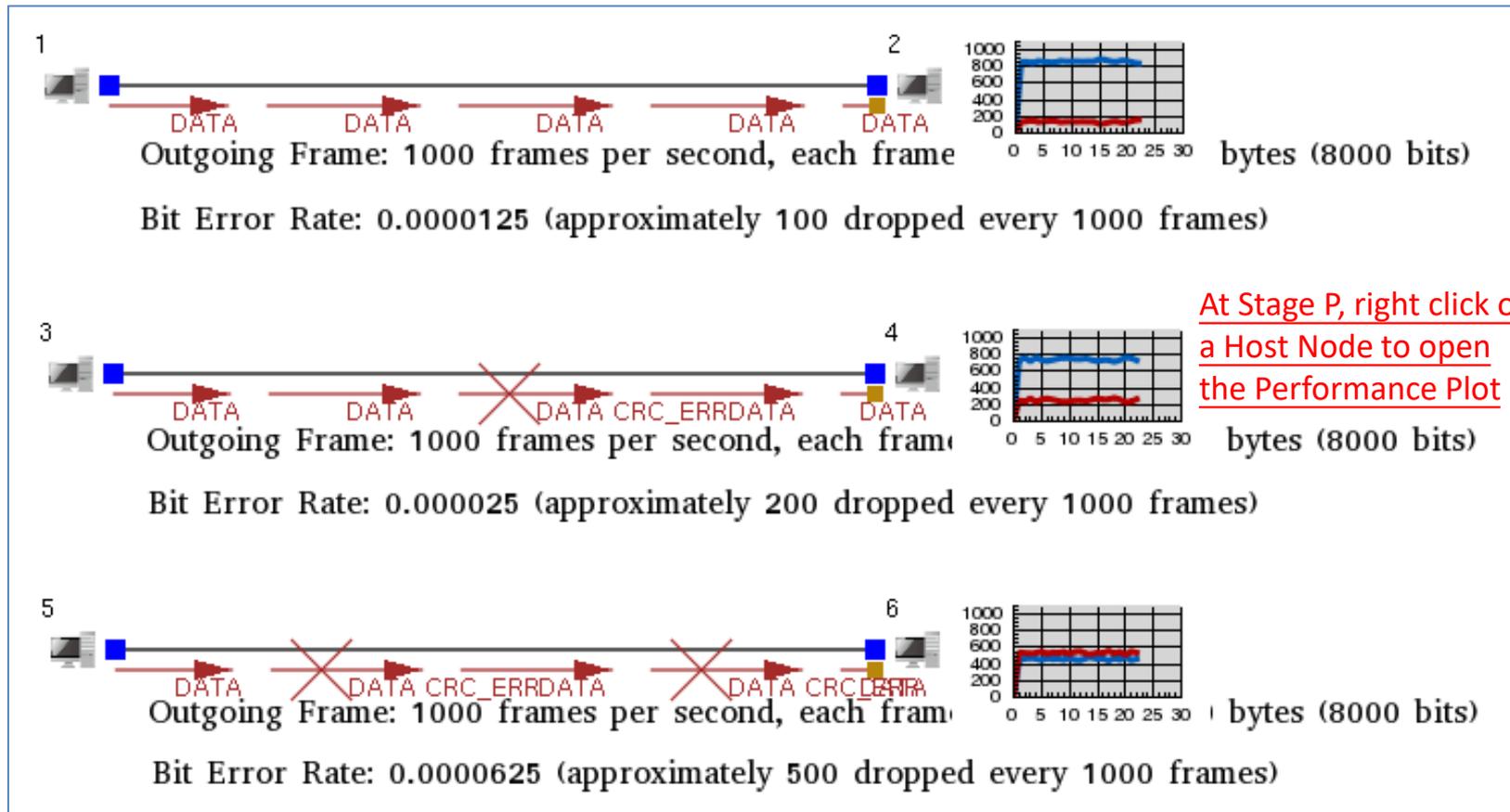
# Change the operating stage to Stage G to generate all simulation configuration files. Then start simulation.

The screenshot displays the EstiNet GUI interface. The main window shows a simulation configuration for a network topology. The 'Run-Panel' menu is open, highlighting 'Start Simulation'. The simulation parameters are set to 1000 frames per second, each frame's length is 1000 bytes (8000 bits). The results for three nodes are as follows:

Node	Outgoing Frame Rate	Bit Error Rate	Approximate Dropped Frames
2	1000 frames per second	0.0000125	approximately 100
4	1000 frames per second	0.000025	approximately 200
6	1000 frames per second	0.0000625	approximately 500

The interface also shows a 'Network Node Portfolio' on the left with icons for Host, Switch, Router, Hub, and Open vSwitch. The bottom status bar indicates the simulation is running at 100% speed with a playback speed of 9 (100 us).

# After simulation, at Stage P, observe the frame error rate on three different links.



# Simulator Experiment

## Transmission Range of Wireless Signal

< Simulation Case >

antenna\_gain\_pattern\_adjustment.xtpl

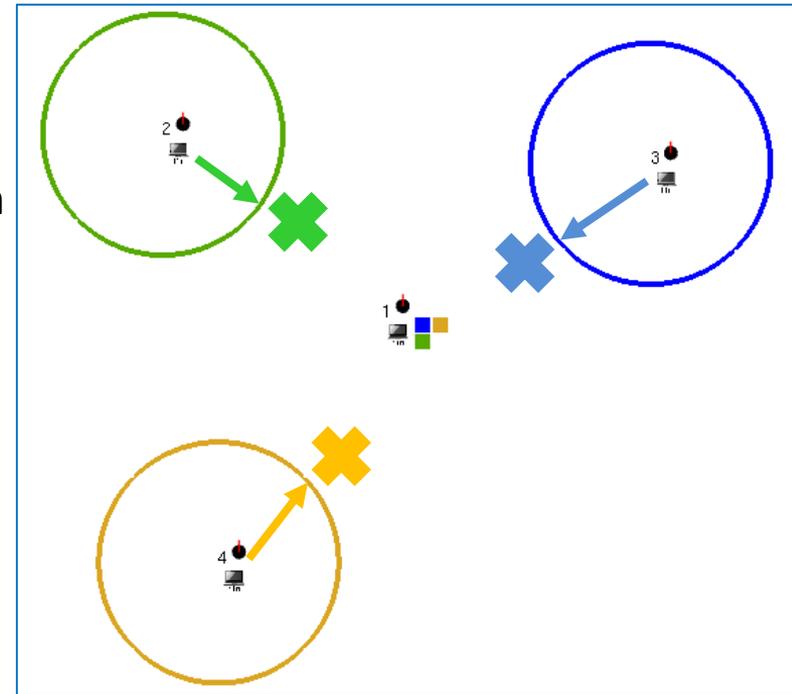
## Factors to determine the transmission range of wireless signals:

- ◆ Antenna gain patterns of both sender site and receiver site
- ◆ Signal transmission power on sender site
- ◆ Signal receiving sensitivity on receiver site
- ◆ Signal frequency and environmental parameters (e.g., terrain, surface object, weather, interference, etc.)

See the graph on the right-hand side. Node 1 located on the center is the signal receiver. Node 2, 3, and 4 located around Node 1 are signal senders. The situation is - the signal transmission ranges of Node 2, 3, and 4 are not far enough so that Node 1 receives no signal.

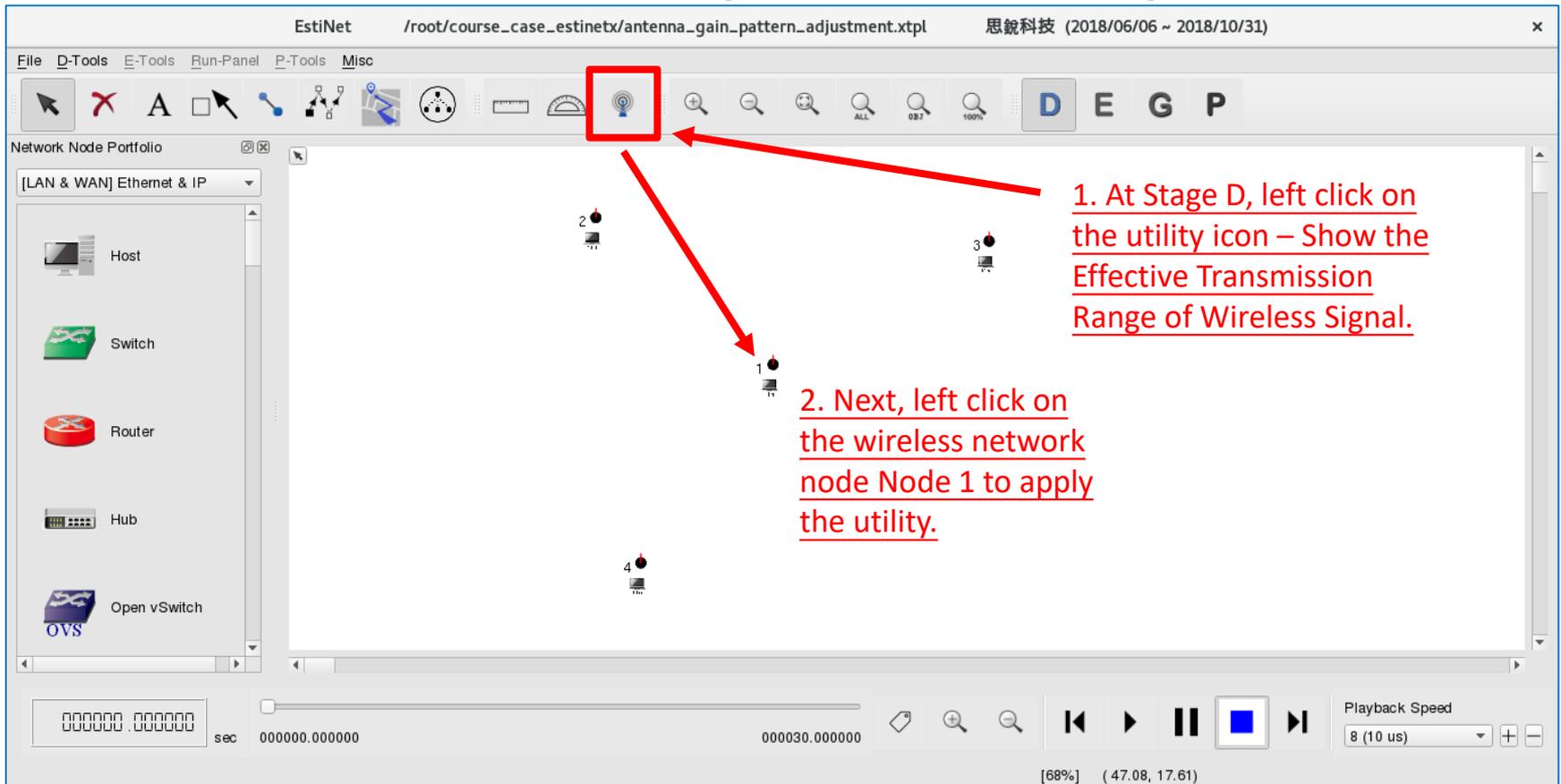
Goal:

According to the above-mentioned factors related to signal transmission range, change the corresponding simulation parameters to let Node 1 receive signals.



# HOW TO SEE THE TRANSMISSION RANGE OF WIRELESS SIGNAL?

# [Step 1] Activate the utility – Show the Effective Transmission Range of Wireless Signal.



The screenshot displays the EstiNet software interface. The title bar shows the file path `/root/course_case_estinetx/antenna_gain_pattern_adjustment.xtpl` and the date range `2018/06/06 ~ 2018/10/31`. The menu bar includes `File`, `D-Tools`, `E-Tools`, `Run-Panel`, `P-Tools`, and `Misc`. The toolbar contains various icons, with the wireless signal utility icon (a blue antenna) highlighted by a red square. A red arrow points from this icon to a wireless network node labeled '1' in the main workspace. Another red arrow points from the same icon to a text box on the right. The left sidebar shows a 'Network Node Portfolio' with categories: `[LAN & WAN] Ethernet & IP`, `Host`, `Switch`, `Router`, `Hub`, and `Open vSwitch`. The bottom status bar shows a timer at `00:00:00.000000` sec, a progress bar at `000030.000000`, and playback controls including a 'Playback Speed' dropdown set to `8 (10 us)`. The bottom right corner displays `[68%] (47.08, 17.61)`.

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.

2. Next, left click on the wireless network node Node 1 to apply the utility.

# [Step 2] On the configuration window, choose to observe the transmission range of wireless signal in the perspective of a signal transmitter.

- ◆ Choose to use a signal transmitter's perspective.
- ◆ Click the button to apply the configured parameters to show the transmission range of wireless signal.

Specify Physical-layer and Channel Model Parameters

Use the Transmitting Node's Perspective  Use the Receiving Node's Perspective

For Transmitting Node's Perspective

Propagation Channel Model

Theoretical Channel Model  Empirical Channel Model

Path Loss Model: 1: Two-Ray-Ground

Fading Model: 0: None

11: Suburban\_1\_9GHz\_TB

PHY Module's Parameters

Frequency (MHz): 5180 C.T.O.I.

TransPower (dbm): -19 C.T.O.I.

ChannelModel Module's Parameters

FadingVar: 10.0

RiceanK: 10.0

AntennaHeight (m): 1.5

SystemLoss: 1.0

AverageBuildingHeight (m): 10.0

StreetWidth (m): 30.0

Set Antenna Gain Pattern and Directivity

Set Wireless Signal Drawing Color

Apply All Parameters to the ChannelModel and PHY Modules & Display the Transmission Range

Do Not Apply Any Parameter to the ChannelModel and PHY Modules & Exit

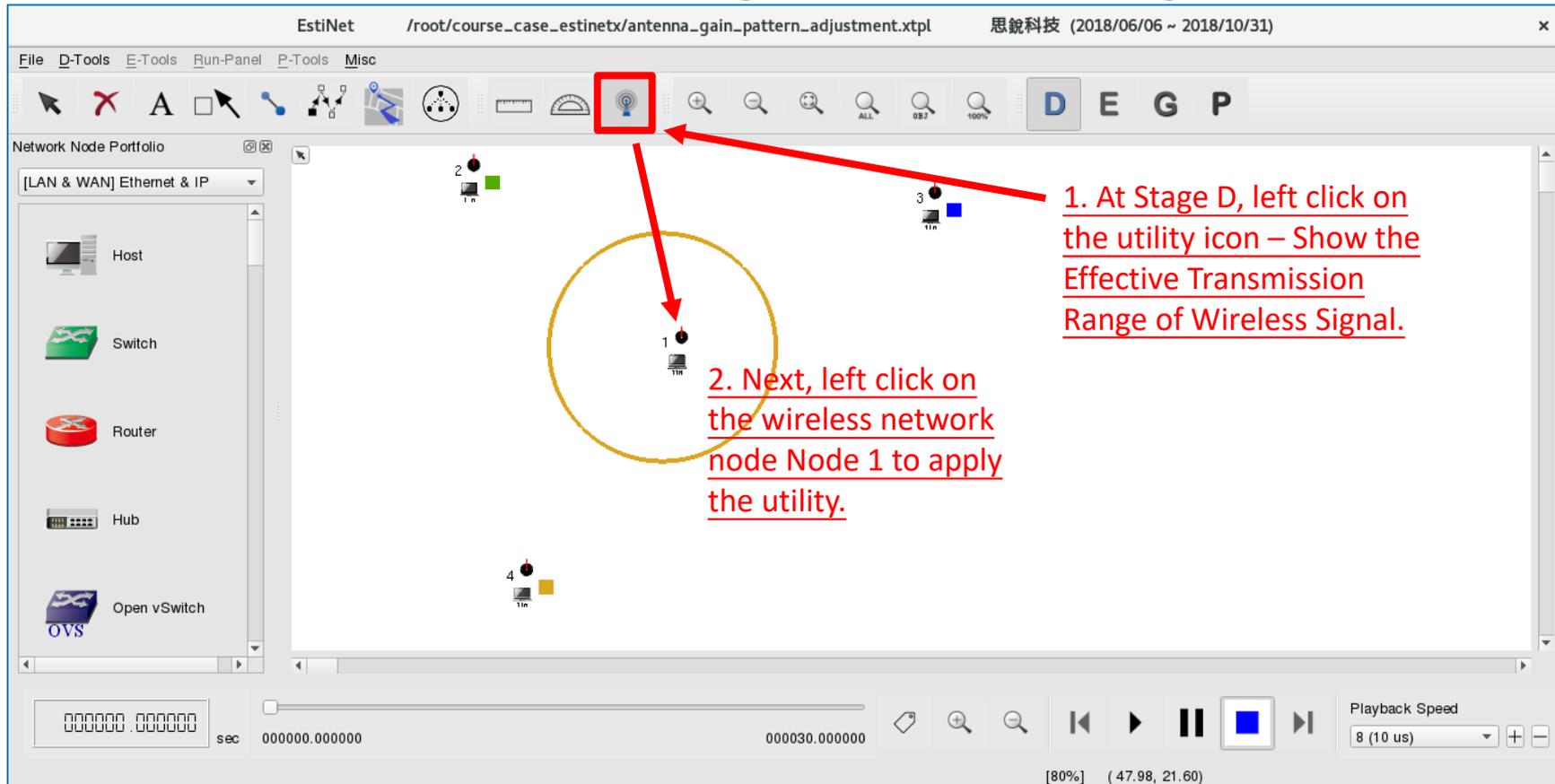
Cancel the Display of the Transmission Range

# [Step 3] Observe Node 1's signal transmission range.

Node 1's signal coverage does not cover the other three nodes.

The little colored squares located aside Node 2, 3, and 4 indicate that they are Node 1's potential signal receivers. However, they are not able to receive Node 1's signal now because of being out of Node 1's signal coverage (the brown circle).

# [Step 4] Again, activate the utility – Show the Effective Transmission Range of Wireless Signal.



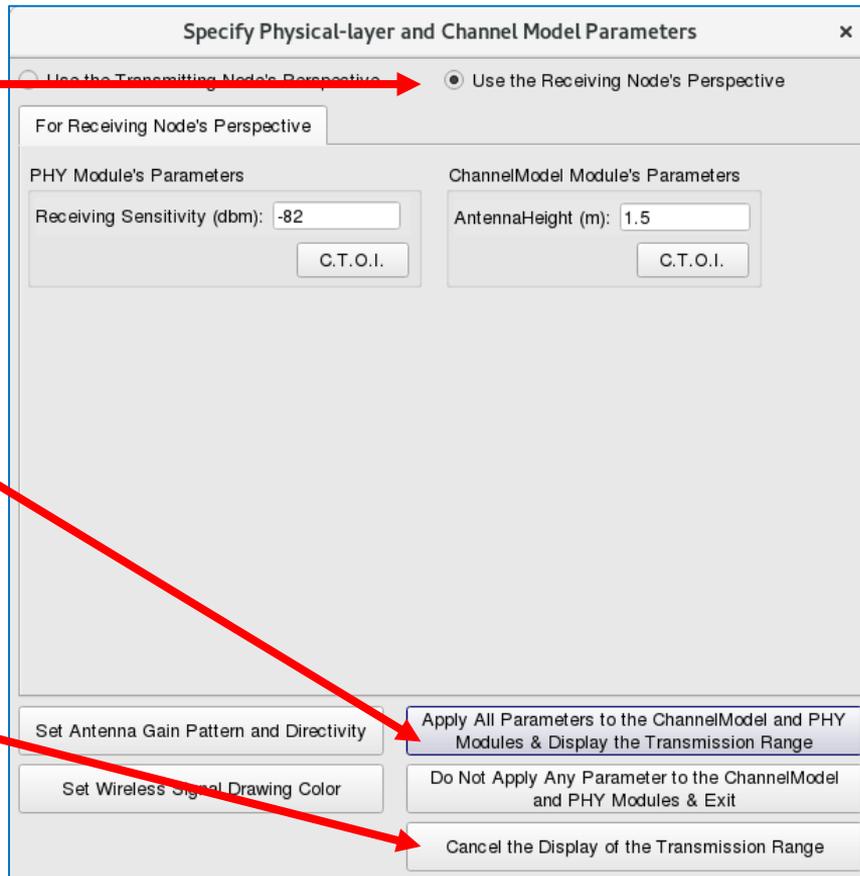
The screenshot shows the EstiNet software interface. The title bar indicates the file path is `/root/course_case_estinetx/antenna_gain_pattern_adjustment.xtpl` and the date is 2018/06/06 ~ 2018/10/31. The interface includes a menu bar (File, D-Tools, E-Tools, Run-Panel, P-Tools, Misc) and a toolbar with various icons. A red box highlights a utility icon in the toolbar, and a red arrow points from it to a wireless network node labeled '1' in the main workspace. A yellow circle highlights node '1'. Another red arrow points from the utility icon to a text box on the right. The left sidebar shows a 'Network Node Portfolio' with categories like Host, Switch, Router, Hub, and Open vSwitch. The bottom status bar shows a timer at 00:00:00.000000, a playback speed of 8 (10 us), and a zoom level of 80%.

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.

2. Next, left click on the wireless network node Node 1 to apply the utility.

# [Step 5] This time, on the configuration window, choose to observe the transmission range of wireless signal in the perspective of a signal receiver.

- ◆ Choose to use a signal receiver's perspective.
- ◆ Click the button to apply the configured parameters to show the transmission range of wireless signal.



- ◆ Press this to cancel the display of wireless signal transmission range.

# [Step 6] Observe the transmission ranges of all the signals that (potentially) are able to be received by Node 1.

The screenshot shows the EstiNet software interface. The main window displays a network diagram with four nodes. Node 1 is at the center, and nodes 2, 3, and 4 are arranged around it. Node 2 is enclosed in a green circle, Node 3 in a blue circle, and Node 4 in a yellow circle. Node 1 has three small colored squares (red, green, blue) next to it. Red arrows point from the text annotations to the nodes and their respective circles.

Node 2, 3 and 4's signal coverages do not cover Node 1.

The little colored squares located aside Node 1 indicate that Node 1 is the potential signal receiver of Node 2, 3, and 4. However, now Node 1 is not able to receive signals from them because of being out of their signal coverages (the three colored circles).

**INCREASE THE TRANSMISSION POWER OF SIGNAL  
ON THE SIGNAL TRANSMITTER TO INCREASE THE  
SIGNAL TRANSMISSION RANGE**

# [Step 1] Activate the utility – Show the Effective Transmission Range of Wireless Signal.

EstiNet /root/course\_case\_estinetx/antenna\_gain\_pattern\_adjustment.xtpl 思銳科技 (2018/06/06 ~ 2018/10/31)

File D-Tools E-Tools Run-Panel P-Tools Misc

Network Node Portfolio [LAN & WAN] Ethernet & IP

- Host
- Switch
- Router
- Hub
- Open vSwitch

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.

2. Next, left click on the wireless network node Node 1 to apply the utility.

Default setting for each node:  
1. Tx Power = -19 dbm  
2. Rx Sensitivity = -82 dbm  
3. Antenna Gain Pattern: 3 dB beamwidth = 360 degrees (Isotropic)  
4. Antenna Pointing: Direction: 90 degrees (Up)

sec 000000.000000 000030.000000 [65%] (27.06, 0.00) Playback Speed 8 (10 us)

# [Step 2] Adjust the transmission power of signal.

- ◆ On the configuration window of Node 1, change the value of TransPower (dbm) from -19 to -10 to increase the transmission power of signal.
  - The unit “dbm” is calculated from a logarithm formula.
  - Assume Power\_mW (milliwatt) is the signal power.  $Power\_dbm = 10 * \log_{10}(Power\_mW / 1\text{ milliwatt})$
  - In other words, “dbm” is the logarithm operation on the ratio of the signal power to 1 milliwatt.
  - Thus, -19 dbm represents the original signal power is 0.01259 milliwatt while -10 dbm represents the original signal power is 0.1 milliwatt. The latter is nearly 7.94 times the former.
- ◆ Press the button C.T.O.I (Copy to Other Interfaces) to copy the modified value to the other three nodes (Node 2, 3, and 4).
  - Increase the transmission power of signal on both signal senders and receivers to achieve bi-directional communication.

Specify Physical-layer and Channel Model Parameters

Use the Transmitting Node's Perspective  Use the Receiving Node's Perspective

For Transmitting Node's Perspective

Propagation Channel Model

Theoretical Channel Model  Empirical Channel Model

Path Loss Model: 1: Two\_Ray\_Ground

Fading Model: 0: None

11: Suburban\_1\_9GHz\_TB

PHY Module's Parameters

Frequency (MHz): 5180 C.T.O.I.

TransPower (dbm): -19 C.T.O.I.

ChannelModel Module's Parameters

FadingVar: 10.0

RiceanK: 10.0

AntennaHeight (m): 1.5

SystemLoss: 1.0

AverageBuildingHeight (m): 10.0

StreetWidth (m): 30.0

Set Antenna Gain Pattern and Directivity

Set Wireless Signal Drawing Color

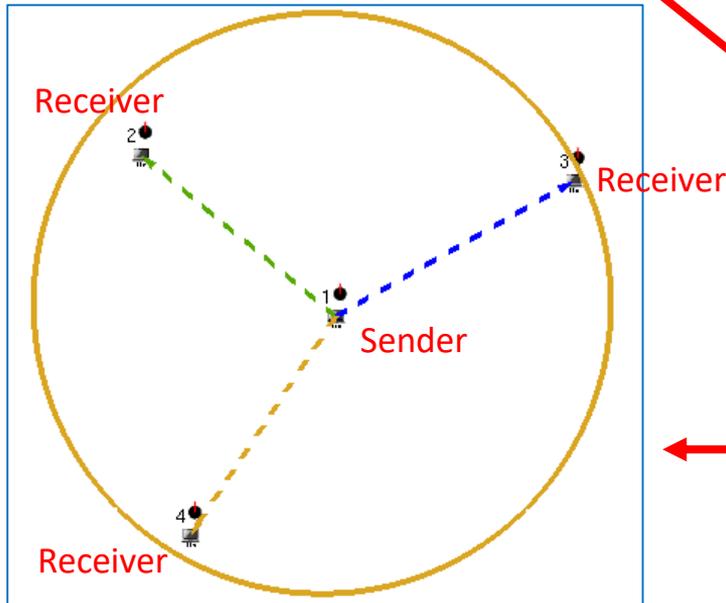
Apply All Parameters to the ChannelModel and PHY Modules & Display the Transmission Range

Do Not Apply Any Parameter to the ChannelModel and PHY Modules & Exit

Cancel the Display of the Transmission Range

# [Step 3] Observe if the signals sent by Node 1 are able to be received by the other three nodes.

- ◆ Choose to use a signal sender's perspective to observe if the transmitted signal can be received by any potential receiver.
- ◆ Click the button to apply the configured parameters to show the transmission range of wireless signal.



**Specify Physical-layer and Channel Model Parameters**

Use the Transmitting Node's Perspective     Use the Receiving Node's Perspective

For Transmitting Node's Perspective

Propagation Channel Model

Theoretical Channel Model    C.T.O.I.

Path Loss Model: 1: Two\_Ray\_Ground

Fading Model: 0: None

Empirical Channel Model

11: Suburban\_1\_9GHz\_TB

PHY Module's Parameters

Frequency (MHz): 5180    C.T.O.I.

TransPower (dbm): -10    C.T.O.I.

ChannelModel Module's Parameters

FadingVar: 10.0

RiceanK: 10.0

AntennaHeight (m): 1.5

SystemLoss: 1.0

AverageBuildingHeight (m): 10.0

StreetWidth (m): 30.0

Set Antenna Gain Pattern and Directivity

**Apply All Parameters to the ChannelModel and PHY Modules & Display the Transmission Range**

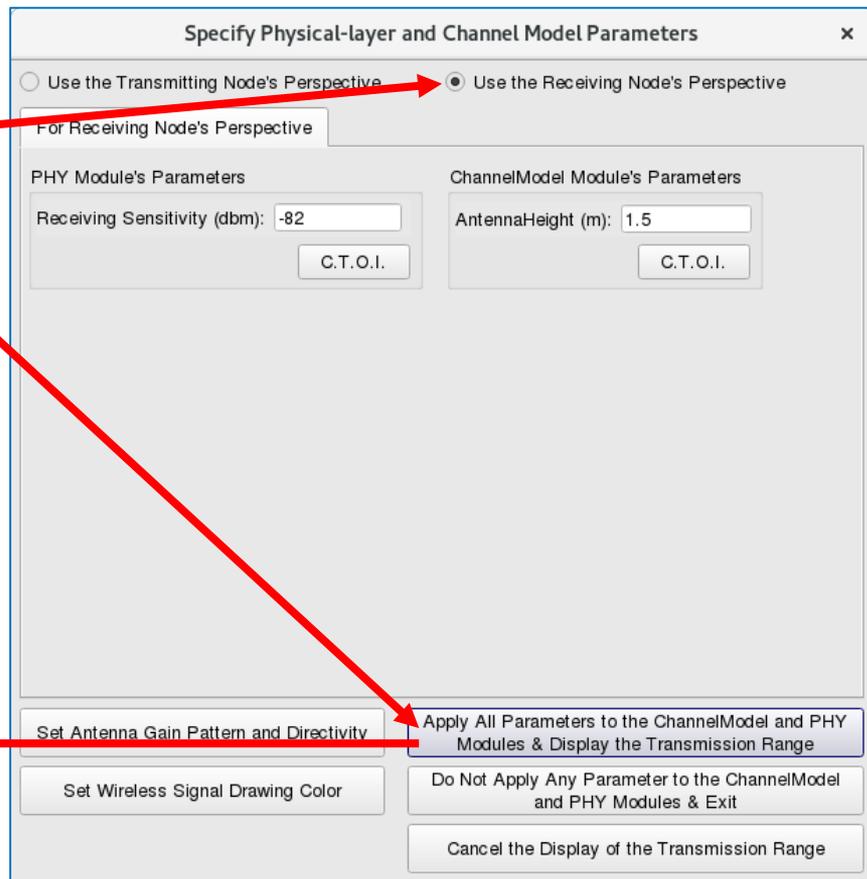
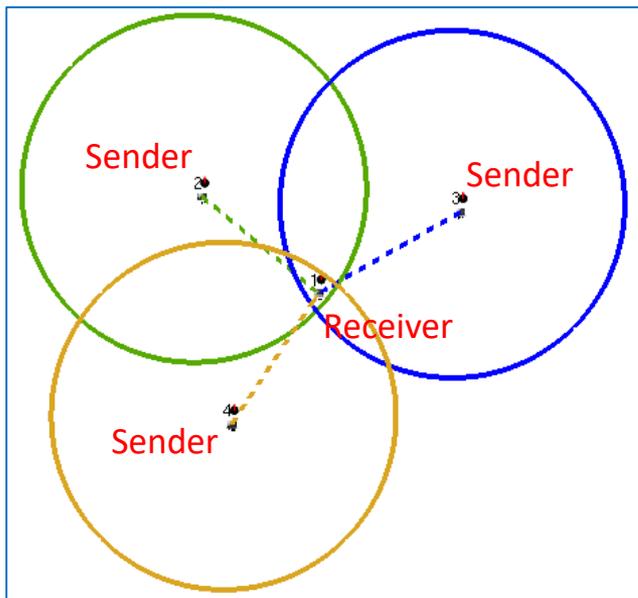
Set Wireless Signal Drawing Color

Do Not Apply Any Parameter to the ChannelModel and PHY Modules & Exit

Cancel the Display of the Transmission Range

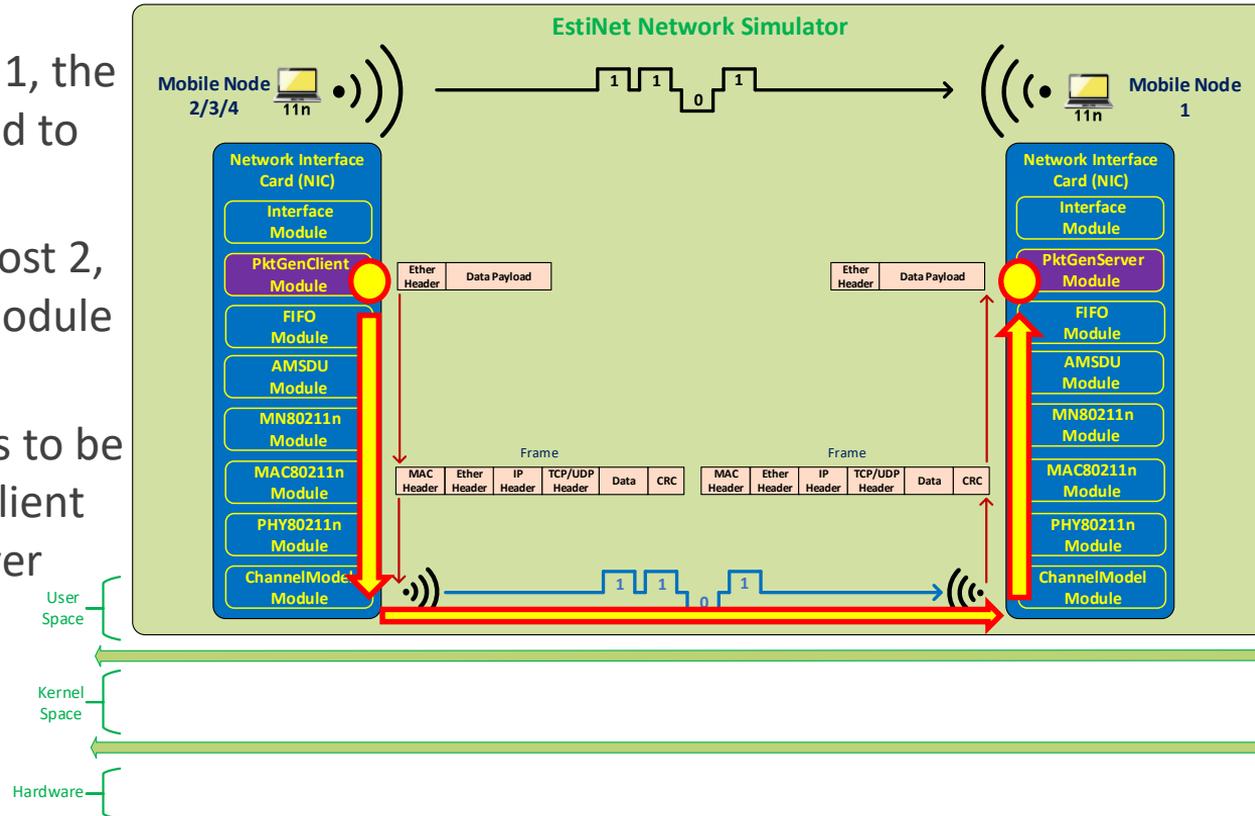
# [Step 4] Observe if the signals sent by other three nodes are able to be received by Node 1.

- ◆ Again, apply the utility “Show the Effective Transmission Range of Wireless Signal” on Node 1.
- ◆ Choose to use a signal receiver’s perspective to observe which sender’s signals can be received by the receiver.
- ◆ Click the button to apply the configured parameters to show the transmission range of wireless signal.



# [Step 5] At Stage E, arrange the PktGen Modules to send/receive frames during simulation.

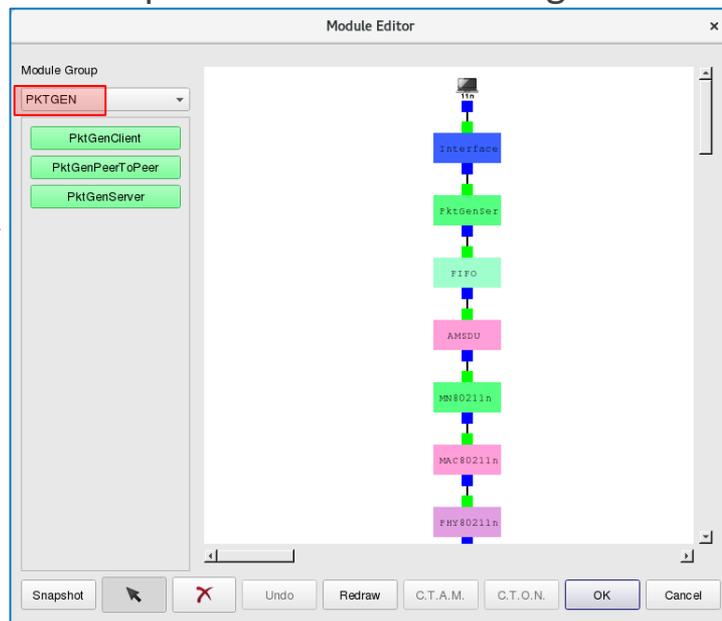
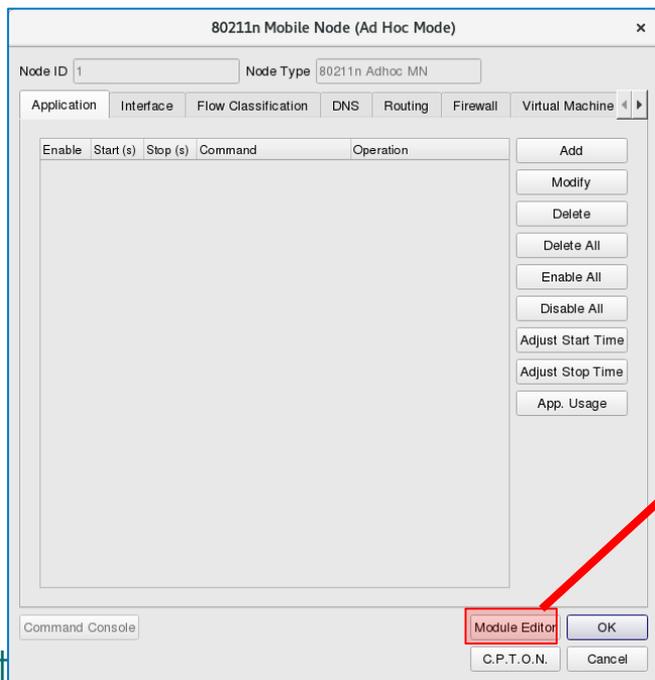
- ◆ On the signal receiver Node 1, the PktGenServer Module is used to receive frames.
- ◆ On the signal transmitters Host 2, 3 and 4, the PktGenClient Module is used to send frames.
- ◆ Note that a FIFO Module has to be inserted below the PktGenClient Module and the PktGenServer Module.



# At Stage E, open the node-editor utility first and then open the module-editor utility to edit protocol stack.

- ◆ At Stage E, double click on any node to open node editor. On the node-editor window, click the Module Editor button to open module editor.

- ◆ On the left side of module-editor window, all available modules are classified by different groups. For example, PktGenServer and PktGenClient modules can be found in the PKTGEN group. Insert required modules into the protocol stack on the right side.



# Configuration of PktGenClient Module

- ◆ Key in the MAC address of receiver Node 1.
- ◆ Key in the length of payload 1000 bytes.
- ◆ Key in the length of header 14 bytes.
- ◆ When a simulation is started, one frame is sent out every 1000 us. In other words, 1000 frames are sent out every 1 sec.

**Parameters Setting**

Destination Node MAC Address

Payload Length  (bytes)

Header Length  (bytes)

Limited Number of Output Packet

Total Number of Output Packet

**Packet Generation Mode**

Fixed Interval

Fixed Generation Interval  (us)

Random Interval

Maximum Random Generation Interval  (us)

Exponential Interval

Mean Payload Sending Rate  (bytes/us)

Ping Pong

Fixed Interval and Ping Pong

Fixed Generation Interval  (us)

Random Interval and Ping Pong

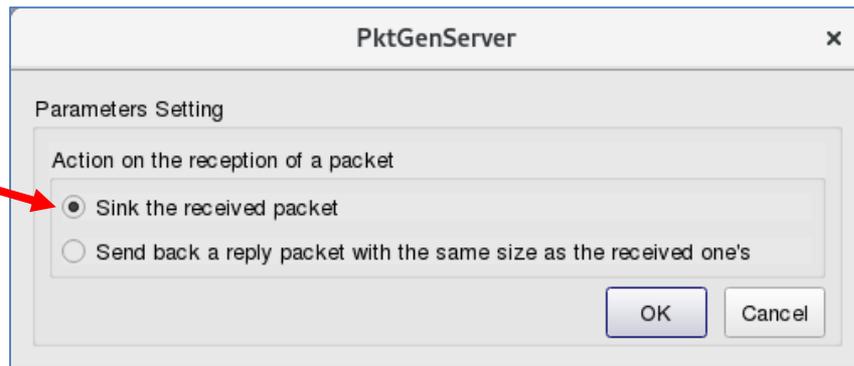
Maximum Random Generation Interval  (us)

Exponential Interval and Ping Pong

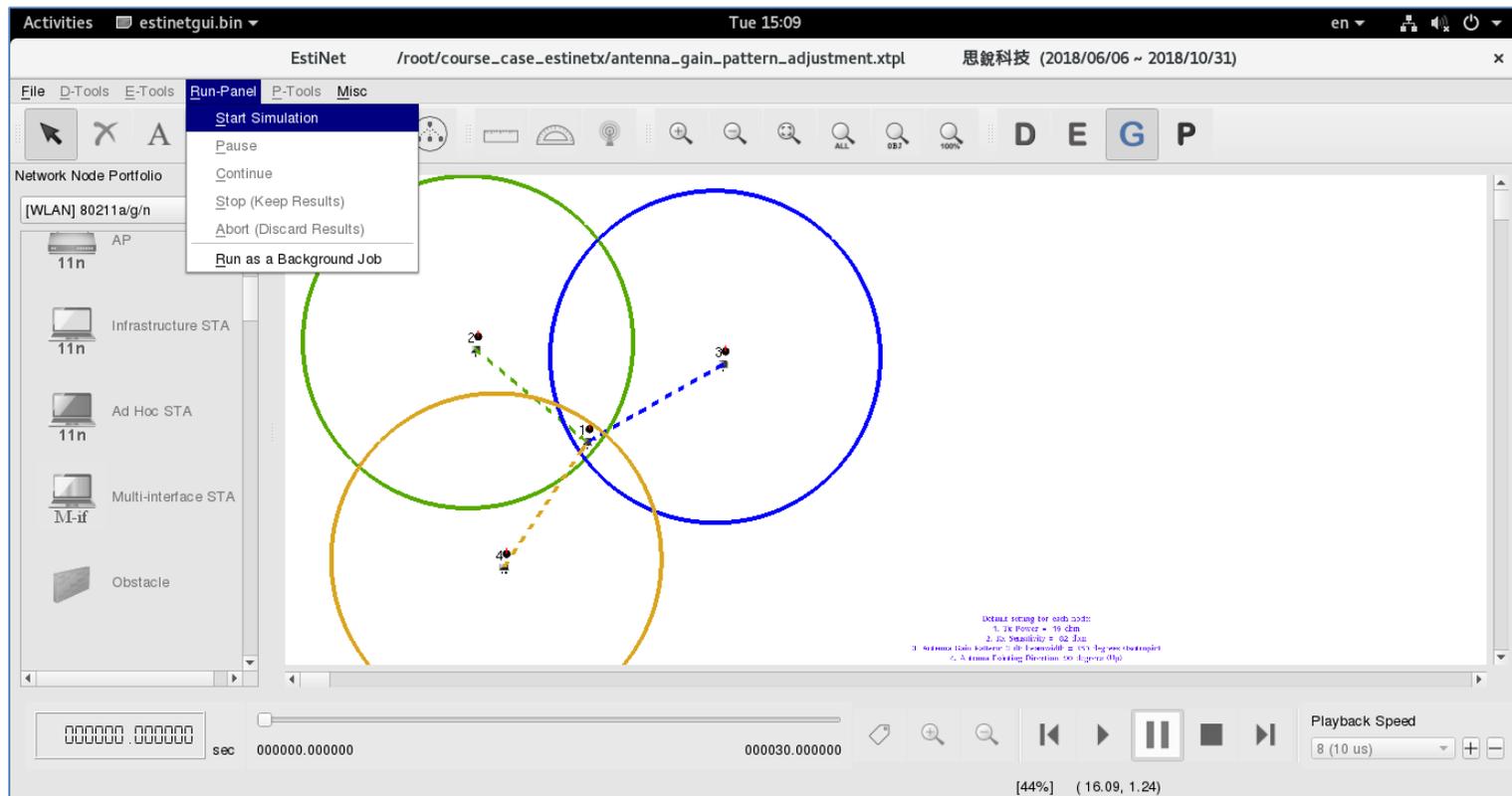
Mean Payload Sending Rate  (bytes/us)

# Configuration of PktGenServer Module

- ◆ Once the receiver Node 1 receives a frame, it drops the frame.

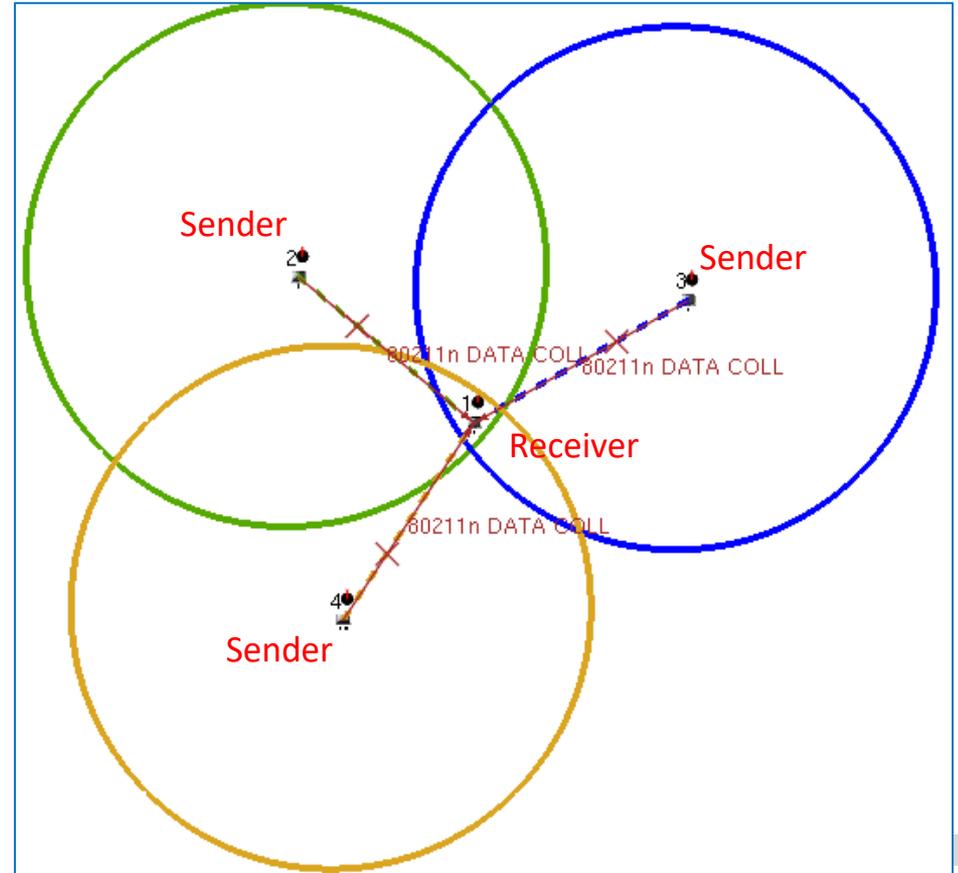


# [Step 6] Change the operating stage to Stage G to generate all simulation configuration files. Then start simulation.



# [Step 7] After simulation, at Stage P, observe the simulation results.

- ◆ At Stage P, the frame animation is displayed according to the simulation results. Check the graph on the right-hand side. The signals sent from Node 2, 3, and 4 are able to reach Node 1. However, those signals collide with each other because they reach Node 1 nearly simultaneously. In this case, Node 1 receives no signal eventually.
- ◆ The problems of signal collision are tackled by data link layer (layer 2). Thus, when watching the frame animation, sometimes a successful frame reception can be seen in both directions.



**INCREASE THE RECEIVING SENSITIVITY OF SIGNAL  
ON THE SIGNAL RECEIVER TO INCREASE THE SIGNAL  
TRANSMISSION RANGE**

# [Step 1] Set those modified simulation parameters back to the default values

- ◆ In the previous experiment, the values of TransPower (dbm) of all nodes (Node 1, 2, 3, and 4) are changed from -19 to -10. Change those values back to -19 first before starting this experiment.

# [Step 2] Activate the utility – Show the Effective Transmission Range of Wireless Signal.

EstiNet /root/course\_case\_estinetx/antenna\_gain\_pattern\_adjustment.xtpl 思銳科技 (2018/06/06 ~ 2018/10/31)

File D-Tools E-Tools Run-Panel P-Tools Misc

Network Node Portfolio [LAN & WAN] Ethernet & IP

- Host
- Switch
- Router
- Hub
- Open vSwitch

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.

2. Next, left click on the wireless network node Node 1 to apply the utility.

Default setting for each node:

1. Tx Power = -19 dbm
2. Rx Sensitivity = -82 dbm
3. Antenna Gain Pattern: 3 dB beamwidth = 360 degrees (Isotropic)
4. Antenna Pointing: Direction: 90 degrees (Up)

sec 000000.000000 000030.000000 [65%] (27.06, 0.00) Playback Speed 8 (10 us)

# [Step 3] Adjust the receiving sensitivity of signal

- ◆ Choose to use a signal receiver's perspective. The following parameter configuration tab will be switched to the specific tab for receiver purpose.
- ◆ Change the value of Receiving Sensitivity (dbm) from -82 to -91. This parameter represents the minimum signal power that is able to be sensed/received by a receiver. When a signal is propagated through the air, its power attenuates gradually along with the path. When the signal reaches a receiver, its power must be larger than the receiving sensitivity of the receiver so that it can be received successfully.
  - The unit “dbm” is calculated from a logarithm formula.
  - Assume RxPower\_mW (milliwatt) is the minimum receiving signal power.  $RxPower\_dbm = 10 * \log_{10} \left( \frac{RxPower\_mW}{1 \text{ milliwatt}} \right)$
  - In other words, “dbm” is the logarithm operation on the ratio of the minimum receiving signal power to 1 milliwatt.
  - Thus, -82 dbm represents the minimum power is  $63.1 * 10^{(-10)}$  milliwatt while -91 dbm represents the minimum power is  $7.94 * 10^{(-10)}$  milliwatt. The latter is nearly 7.94 times lower than the former. That means, a signal can be transmitted farther and still be received.

Specify Physical-layer and Channel Model Parameters

Use the Transmitting Node's Perspective  Use the Receiving Node's Perspective

For Receiving Node's Perspective

PHY Module's Parameters

Receiving Sensitivity (dbm): -82 C.T.O.I.

ChannelModel Module's Parameters

AntennaHeight (m): 1.5 C.T.O.I.

Set Antenna Gain Pattern and Directivity

Apply All Parameters to the ChannelModel and PHY Modules & Display the Transmission Range

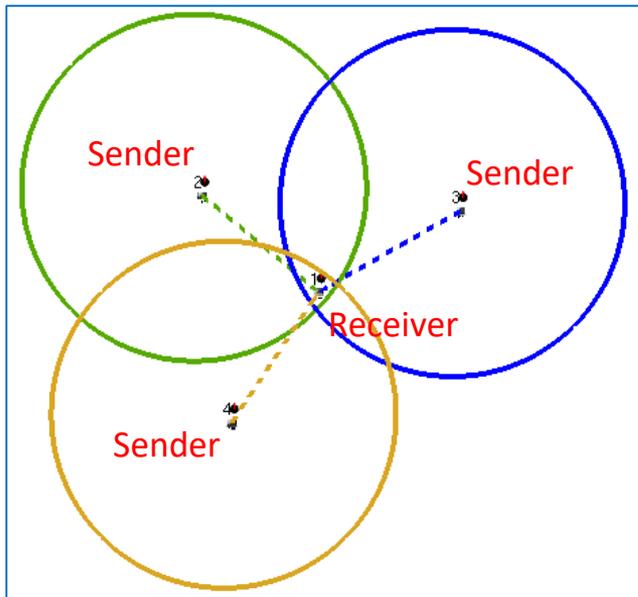
Set Wireless Signal Drawing Color

Do Not Apply Any Parameter to the ChannelModel and PHY Modules & Exit

Cancel the Display of the Transmission Range

# [Step 4] Observe if the signals sent by other three nodes are able to be received by Node 1.

- Click the button to apply the configured parameters to show the transmission range of wireless signal.



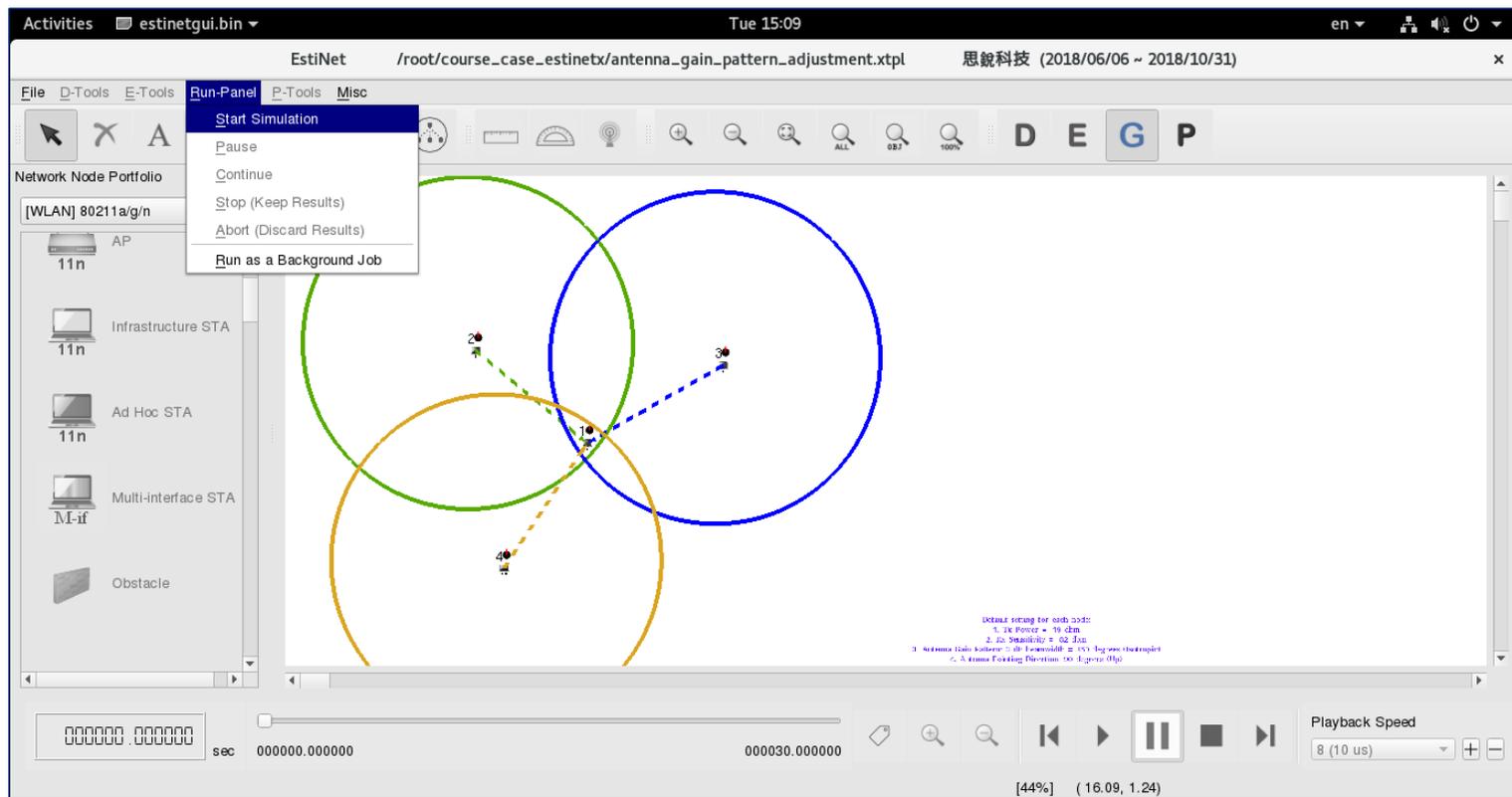
### Specify Physical-layer and Channel Model Parameters

Use the Transmitting Node's Perspective     Use the Receiving Node's Perspective

For Receiving Node's Perspective

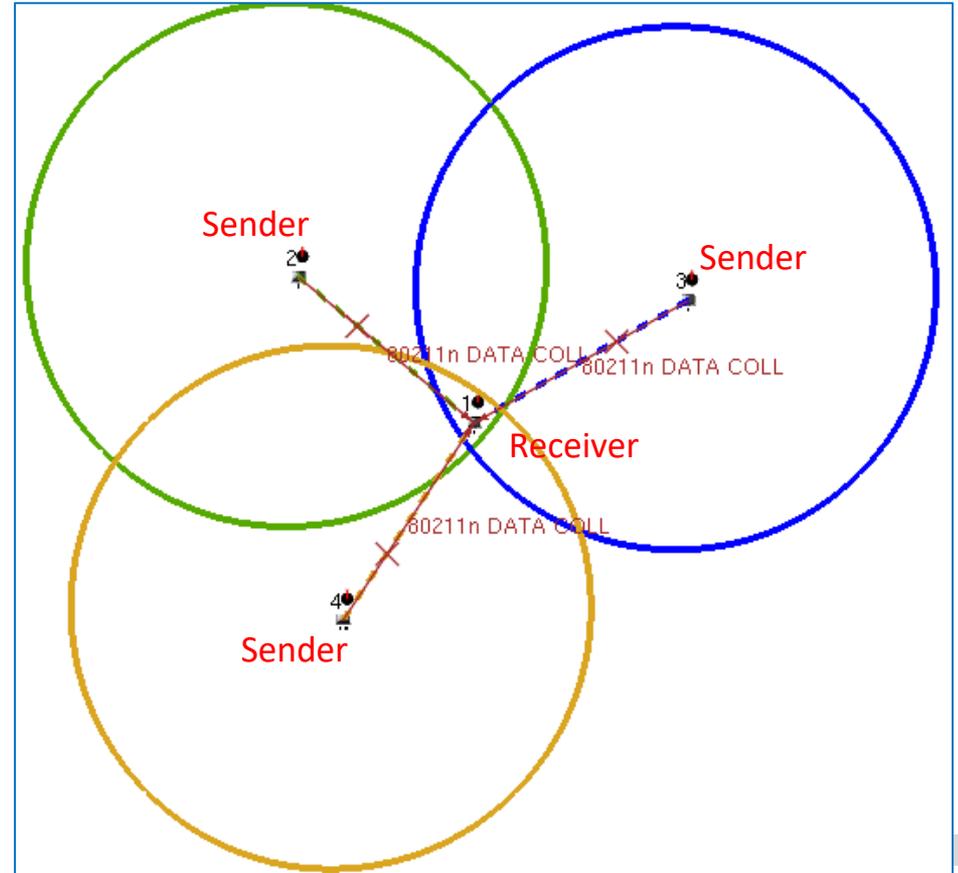
PHY Module's Parameters	ChannelModel Module's Parameters
Receiving Sensitivity (dbm): <input type="text" value="-91"/>	AntennaHeight (m): <input type="text" value="1.5"/>
<input type="button" value="C.T.O.I."/>	<input type="button" value="C.T.O.I."/>

# [Step 5] Change the operating stage to Stage G to generate all simulation configuration files. Then start simulation.



# [Step 6] After simulation, at Stage P, observe the simulation results.

- ◆ At Stage P, the frame animation is displayed according to the simulation results. Check the graph on the right-hand side. The signals sent from Node 2, 3, and 4 are able to reach Node 1. However, those signals collide with each other because they reach Node 1 nearly simultaneously. In this case, Node 1 receives no signal eventually.
- ◆ The problems of signal collision are tackled by data link layer (layer 2). Thus, when watching the frame animation, sometimes a successful frame reception can be seen in only one direction (Node 2/3/4 to Node 1).



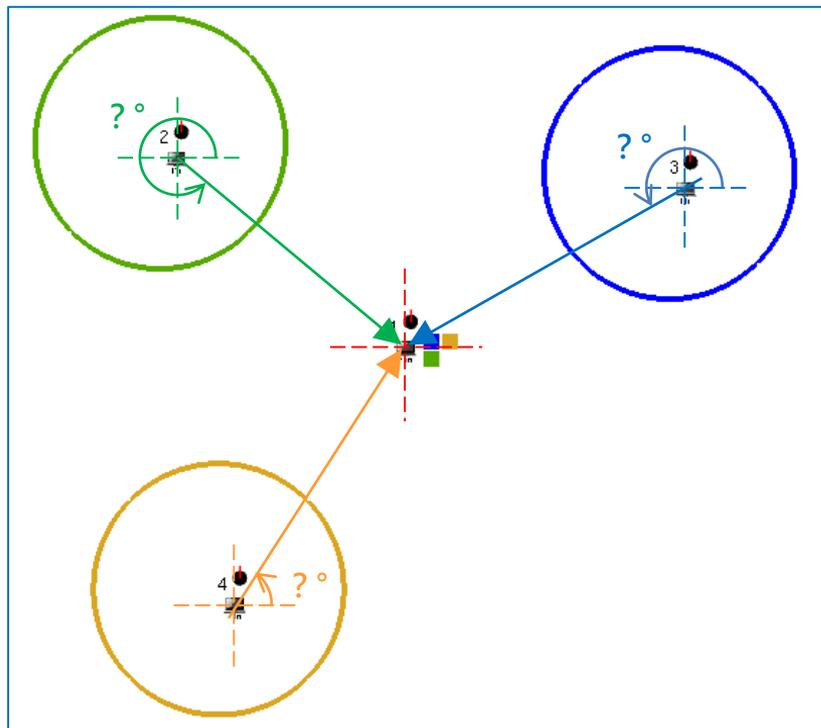
**ADJUST THE ANTENNA GAIN PATTERN ON THE  
SIGNAL TRANSMITTER TO INCREASE THE  
SIGNAL TRANSMISSION RANGE**

# [Step 1] Set the modified simulation parameter back to the default value

- ◆ In the previous experiment, the value of Receiving Sensitivity (dbm) of Node 1 is changed from -82 to -91. Change the value back to -82 first before starting this experiment.

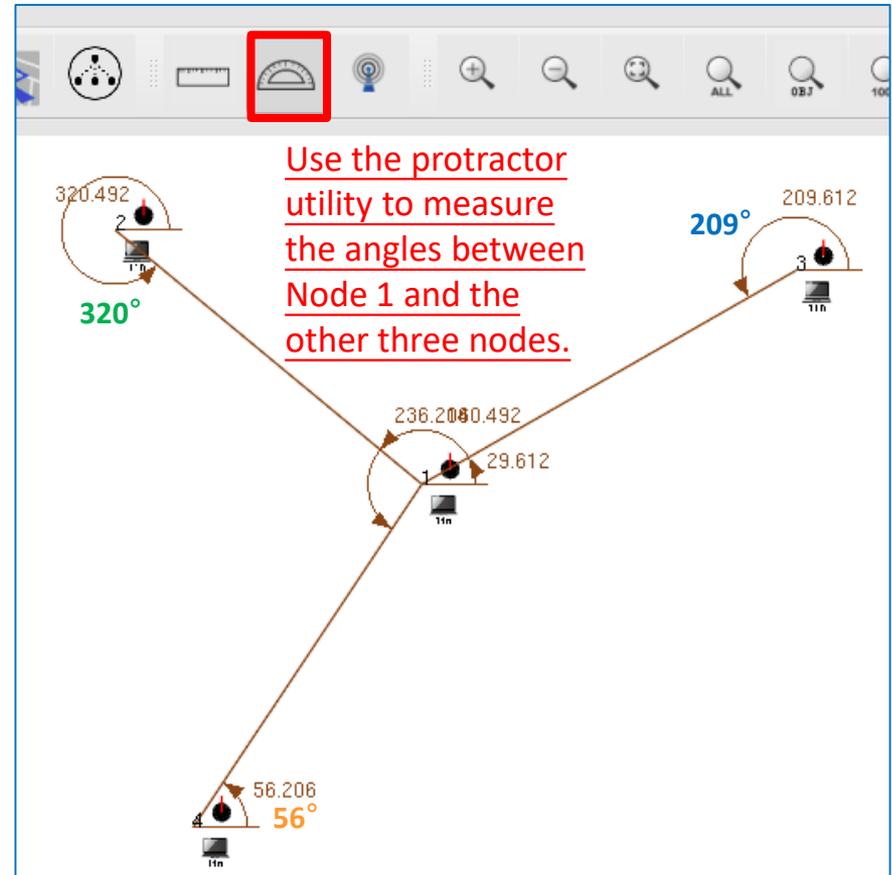
## [Step 2] The principle of adjusting antenna gain pattern to increase the transmission range of signal

- ◆ The default antenna gain pattern is isotropic ( $360^\circ$ ). If an isotropic antenna is used, the available power is used to emit signals in all directions.
- ◆ If a directional antenna is used, the available power is used to emit signals in a specific direction.
- ◆ If the available power is the same, a directional antenna emits signals farther than an isotropic antenna in a specific direction.
- ◆ Thus, we are going to change the antenna gain pattern of Node 2, 3, and 4's antennas from isotropic to directional. In this way, their signal transmission range will be increased to cover Node 1.



# [Step 3] Measure the relative angles between Node 2/3/4 and Node 1

- ◆ Use the protractor utility to measure the relative angles between Node 2/3/4 and Node 1.
  - ❑ Node 2 to Node 1  $\rightarrow 320^\circ$
  - ❑ Node 3 to Node 1  $\rightarrow 209^\circ$
  - ❑ Node 4 to Node 1  $\rightarrow 56^\circ$



# [Step 4] Activate the utility – Show the Effective Transmission Range of Wireless Signal.

EstiNet /root/course\_case\_estinetx/antenna\_gain\_pattern\_adjustment.xtpl 思銳科技 (2018/06/06 ~ 2018/10/31)

File D-Tools E-Tools Run-Panel P-Tools Misc

Network Node Portfolio [LAN & WAN] Ethernet & IP

- Host
- Switch
- Router
- Hub
- Open vSwitch

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.

2. Next, left click on the wireless network node Node 2 to apply the utility.

Default setting for each node:

1. Tx Power = -19 dbm
2. Rx Sensitivity = -82 dbm
3. Antenna Gain Pattern: 3 dB beamwidth = 360 degrees (Isotropic)
4. Antenna Pointing: Direction: 90 degrees (Up)

sec 000000.000000 000030.000000 [65%] (27.06, 0.00) Playback Speed 8 (10 us)

# [Step 5] Adjust Node 2's antenna gain pattern and antenna's pointing direction

**Specify Physical-layer and Channel Model Parameters**

Use the Transmitting Node's Perspective     Use the Receiving Node's Perspective

For Transmitting Node's Perspective    **1. Use a signal transmitter's perspective**

Propagation Channel Model

Theoretical Channel Model    C.T.O.I.

Path Loss Model: 1: Two\_Ray\_Ground

Fading Model: 0: None

Empirical Channel Model

11: Suburban\_1\_9GHz\_TB

PHY Module's Parameters    Channel Model Module's Parameters

Frequency (MHz): 5180    C.T.O.I.    FadingVar: 10.0

TransPower (dbm): -10    C.T.O.I.    RiceanK: 10.0

AntennaHeight (m): 1.5

SystemLoss: 1.0

AverageBuildingHeight (m): 10.0

StreetWidth (m): 30.0

**2. Set antenna gain pattern and directivity**

**Set Antenna Gain Pattern and Directivity**

Set Wireless Signal Drawing Color

Apply All Parameters to the Channel Model and PHY Modules & Display the Transmission Range

Do Not Apply Any Parameter to the Channel Model and PHY Modules & Exit

Cancel the Display of the Transmission Range

**Set Antenna Gain Pattern and Directivity**

Antenna Gain Pattern

Use Predefined Antenna Gain Pattern    C.T.O.I.

3 dB Beamwidth: 60 degrees    **3. Set antenna gain pattern**

360-degree Antenna Gain Pattern    120-degree Antenna Gain Pattern    60-degree Antenna Gain Pattern

Use User-defined Antenna Gain Pattern

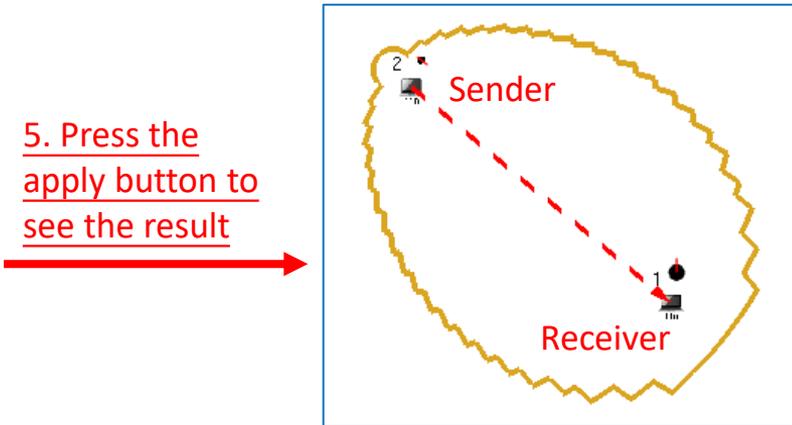
Antenna Gain Pattern File:    File Browser

Antenna Directivity

Pointing Direction (Right: 0, Up: 90, Left: 180, Down: 270): 320 degree(s)    **4. Set antenna pointing direction**

Rotating Angular Speed (Counterclockwise): 0 degree(s)/sec    C.T.O.I.

OK    Cancel



# [Step 6] Activate the utility – Show the Effective Transmission Range of Wireless Signal.

The screenshot shows the EstiNet software interface. The title bar indicates the file path: /root/course\_case\_estinetx/physical\_layer/antenna\_gain\_pattern\_adjustment.xtpl. The interface includes a menu bar (File, D-Tools, E-Tools, Run-Panel, P-Tools, Misc), a toolbar with various icons, and a main workspace. On the left, there is a 'Network Node Portfolio' panel with a dropdown menu set to '[LAN & WAN] Ethernet & IP'. Below this, there are icons for Host, Switch, Router, Hub, and Open vSwitch (OVS). The main workspace displays a network diagram with several nodes. A yellow, irregularly shaped area represents the effective transmission range of a wireless signal, centered around a node labeled '2'. A red dashed line connects node '2' to another node labeled '3'. A red box highlights the utility icon (a blue circle with a white signal tower) in the toolbar. Two red arrows point from this icon to node '3' and to the yellow transmission range area. A red text box on the right contains the following instructions:

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.
2. Next, left click on the wireless network node Node 3 to apply the utility.

At the bottom right of the workspace, there is a text box with the following text:

Default setting for each node:  
1. Tx Power = -15 dbm  
2. Rx Sensitivity = -82 dbm  
3. Antenna Gain Pattern: 3 dBi beamwidth = 360 degrees (Isotropic)  
4. Antenna Pointing (direction): 80 degrees (Up)

The bottom status bar shows a timer (00:00:00.000000 sec), a progress bar (000000.000000 to 000030.000000), a zoom level of [58%], and a playback speed of 8 (10 us).

# [Step 7] Adjust Node 3's antenna gain pattern and antenna's pointing direction

**Specify Physical-layer and Channel Model Parameters**

Use the Transmitting Node's Perspective     Use the Receiving Node's Perspective

For Transmitting Node's Perspective    **1. Use a signal transmitter's perspective**

Propagation Channel Model

Theoretical Channel Model    C.T.O.I.

Path Loss Model: 1: Two\_Ray\_Ground

Fading Model: 0: None

Empirical Channel Model

11: Suburban\_1\_9GHz\_TB

PHY Module's Parameters

Frequency (MHz): 5180    C.T.O.I.

TransPower (dbm): -10    C.T.O.I.

ChannelModel Module's Parameters

FadingVar: 10.0

RiceanK: 10.0

AntennaHeight (m): 1.5

SystemLoss: 1.0

AverageBuildingHeight (m): 10.0

StreetWidth (m): 30.0

**2. Set antenna gain pattern and directivity**

**Set Antenna Gain Pattern and Directivity**

Set Wireless Signal Drawing Color

**Apply All Parameters to the ChannelModel and PHY Modules & Display the Transmission Range**

Do Not Apply Any Parameter to the ChannelModel and PHY Modules & Exit

Cancel the Display of the Transmission Range

**Set Antenna Gain Pattern and Directivity**

Antenna Gain Pattern

Use Predefined Antenna Gain Pattern    C.T.O.I.

**3 dB Beamwidth: 60 degrees**    **3. Set antenna gain pattern**

360-degree Antenna Gain Pattern    120-degree Antenna Gain Pattern    60-degree Antenna Gain Pattern

Use User-defined Antenna Gain Pattern

Antenna Gain Pattern File:    File Browser

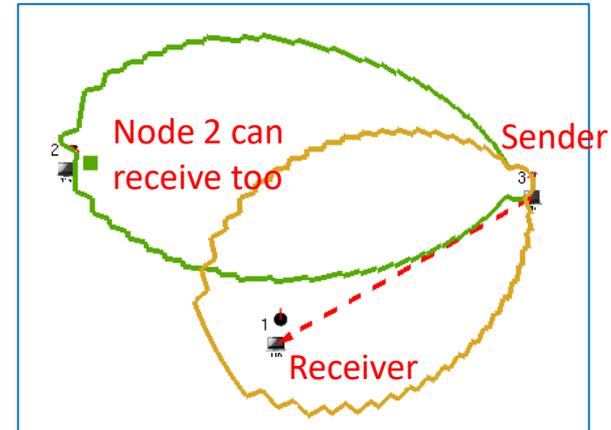
Antenna Directivity

**Pointing Direction (Right: 0, Up: 90, Left: 180, Down: 270): 209 degree(s)**    **4. Set antenna pointing direction**

Rotating Angular Speed (Counterclockwise): 0 degree(s)/sec    C.T.O.I.

OK    Cancel

**5. Press the apply button to see the result**



# [Step 8] Activate the utility – Show the Effective Transmission Range of Wireless Signal.

EstiNet /root/course\_case\_estinetx/physical\_layer/antenna\_gain\_pattern\_adjustment.xtpl 思銳科技 (2018/06/06 ~ 2018/10/31)

File D-Tools E-Tools Run-Panel P-Tools Misc

Network Node Portfolio [LAN & WAN] Ethernet & IP

- Host
- Switch
- Router
- Hub
- Open vSwitch

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.

2. Next, left click on the wireless network node Node 4 to apply the utility.

Default setting for each node:

1. Tx Power = -15 dbm
2. Rx Sensitivity = -82 dbm
3. Antenna Gain Pattern: 3 dB Beamwidth = 360 degrees (Isotropic)
4. Antenna Pointing Direction: 00 degrees (Up)

sec 000000.000000 000030.000000 [52%] (62.16, 16.09)

Playback Speed 8 (10 us)

# [Step 9] Adjust Node 4's antenna gain pattern and antenna's pointing direction

**Specify Physical-layer and Channel Model Parameters**

Use the Transmitting Node's Perspective     Use the Receiving Node's Perspective

For Transmitting Node's Perspective **1. Use a signal transmitter's perspective**

Propagation Channel Model

Theoretical Channel Model    C.T.O.I.

Path Loss Model: 1: Two\_Ray\_Ground

Fading Model: 0: None

Empirical Channel Model

11: Suburban\_1\_9GHz\_TB

PHY Module's Parameters

Frequency (MHz): 5180    C.T.O.I.

TransPower (dbm): -10    C.T.O.I.

ChannelModel Module's Parameters

FadingVar: 10.0

RiceanK: 10.0

AntennaHeight (m): 1.5

SystemLoss: 1.0

AverageBuildingHeight (m): 10.0

StreetWidth (m): 30.0

**2. Set antenna gain pattern and directivity**

**Set Antenna Gain Pattern and Directivity**

Set Wireless Signal Drawing Color

Apply All Parameters to the ChannelModel and PHY Modules & Display the Transmission Range

Do Not Apply Any Parameter to the ChannelModel and PHY Modules & Exit

Cancel the Display of the Transmission Range

**Set Antenna Gain Pattern and Directivity**

Antenna Gain Pattern

Use Predefined Antenna Gain Pattern    C.T.O.I.

3 dB Beamwidth: 60 degrees **3. Set antenna gain pattern**

360-degree Antenna Gain Pattern    120-degree Antenna Gain Pattern    60-degree Antenna Gain Pattern

Use User-defined Antenna Gain Pattern

Antenna Gain Pattern File:    File Browser

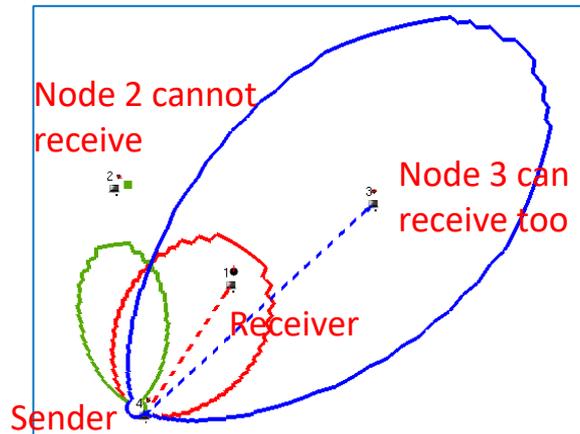
Antenna Directivity

Pointing Direction (Right: 0, Up: 90, Left: 180, Down: 270): 56 degree(s) **4. Set antenna pointing direction**

Rotating Angular Speed (Counterclockwise): 0 degree(s)/sec    C.T.O.I.

OK    Cancel

**5. Press the apply button to see the result**



# [Step 10] Activate the utility – Show the Effective Transmission Range of Wireless Signal.

EstiNet /root/course\_case\_estinetx/physical\_layer/antenna\_gain\_pattern\_adjustment.xtpl 思銳科技 (2018/06/06 ~ 2018/10/31)

File D-Tools E-Tools Run-Panel P-Tools Misc

Network Node Portfolio [LAN & WAN] Ethernet & IP

- Host
- Switch
- Router
- Hub
- Open vSwitch

1. At Stage D, left click on the utility icon – Show the Effective Transmission Range of Wireless Signal.

2. Next, left click on the wireless network node Node 1 to apply the utility.

Default setting for each node:  
1. The Force = 10 dBm  
2. The Swept freq. = 42 GHz  
3. Antenna Gain Pattern = 45 degrees (width) = 90 degrees (isotropic)  
4. An antenna pointing Direction = 90 degrees (0, 1)

000000.000000 sec 000000.000000 000030.000000

Playback Speed 8 (10 us)

[42%] (113.12, 2.93)

# [Step 11] On Node 1, as a signal receiver, observe the signal transmission ranges of other three nodes after the adjustment

Specify Physical-layer and Channel Model Parameters

Use the Transmitting Node's Perspective  Use the Receiving Node's Perspective

For Receiving Node's Perspective **1. Use a signal receiver's perspective**

PHY Module's Parameters  
Receiving Sensitivity (dbm):  C.T.O.I.

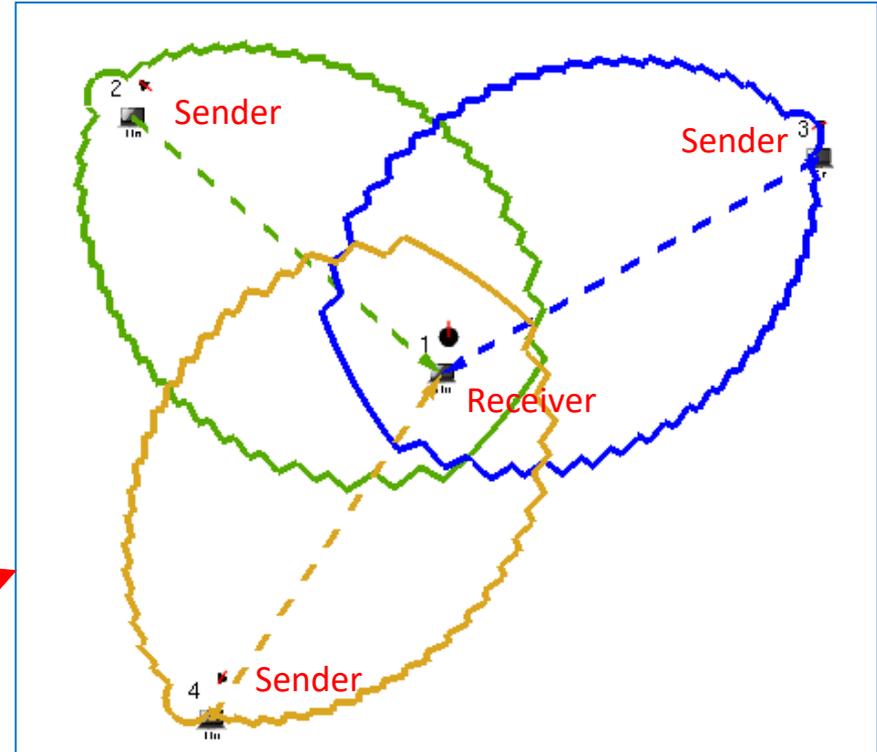
ChannelModel Module's Parameters  
AntennaHeight (m):  C.T.O.I.

**2. Press the apply button to see the result**

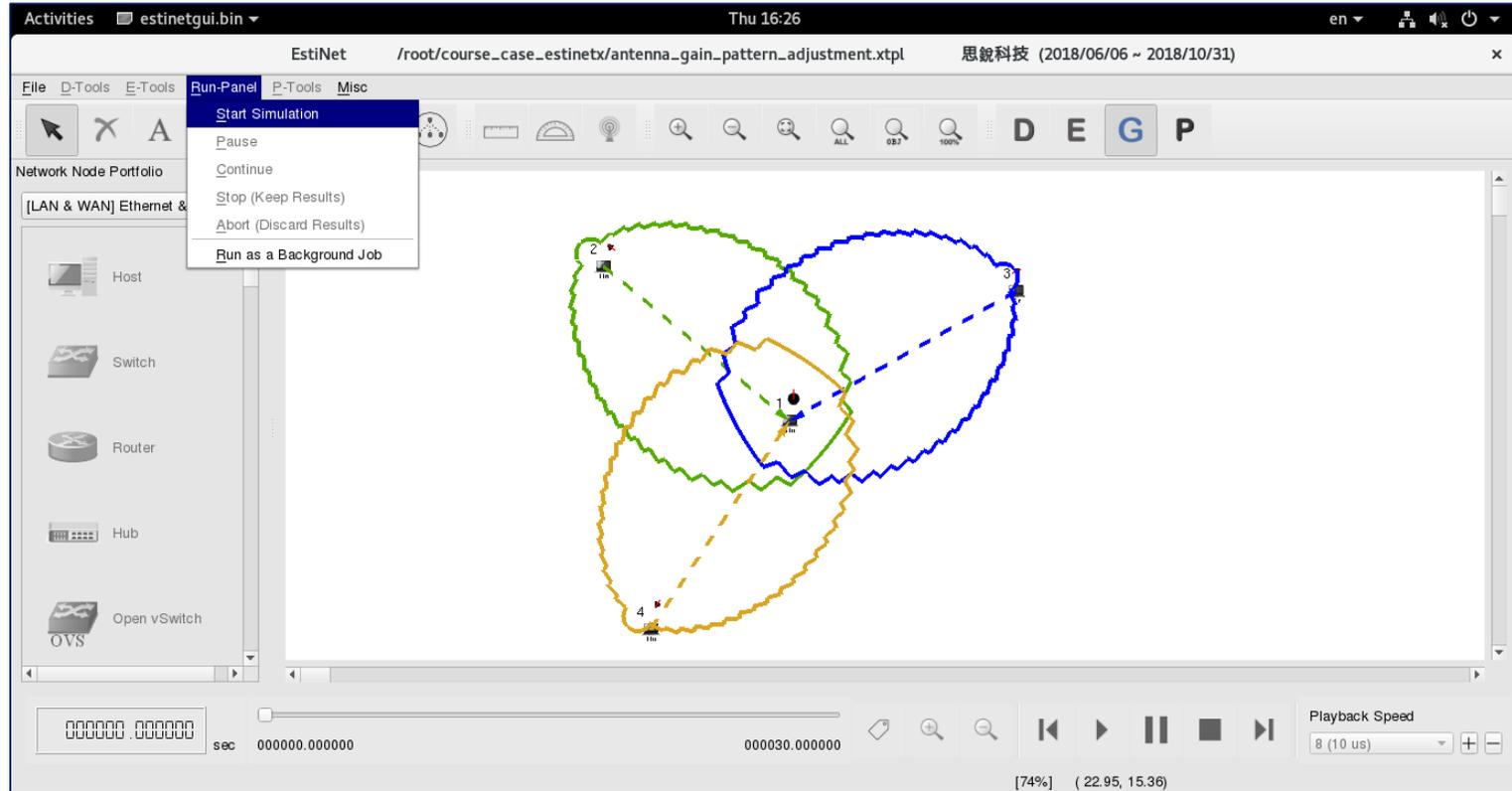
Apply All Parameters to the ChannelModel and PHY Modules & Display the Transmission Range

Do Not Apply Any Parameter to the ChannelModel and PHY Modules & Exit

Cancel the Display of the Transmission Range

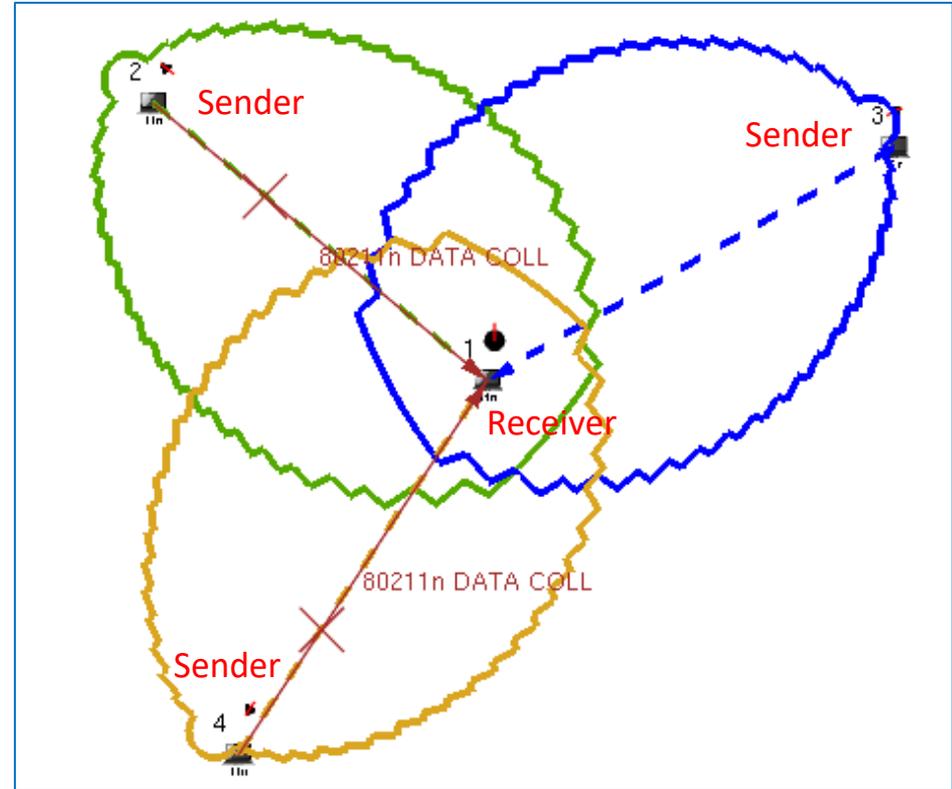


[Step 12] Change the operating stage to Stage G to generate all simulation configuration files. Then start simulation.



# [Step 13] After simulation, at Stage P, observe the simulation results.

- ◆ At Stage P, the frame animation is displayed according to the simulation results. Check the graph on the right-hand side. The signals sent from Node 2, 3, and 4 are able to reach Node 1. If more than one signal reach Node 1 nearly simultaneously, these signals collide with each other.
- ◆ The problems of signal collision are tackled by data link layer (layer 2). Thus, when watching the frame animation, sometimes a successful frame reception can be seen in both directions.



# **ADJUST SIGNAL FREQUENCY AND ENVIRONMENTAL PARAMETERS TO OBSERVE SIGNAL TRANSMISSION RANGE**

# Configure signal frequency and environmental parameters (e.g., terrain, surface object, weather, interference, etc.)

- ◆ While developing a communication standard (including physical layer and data link layer), experts determine the used signal frequency and required bandwidth according to the target data rates and environmental parameters where a communication channel is applied to.
- ◆ On EstiNet X simulator, the used signal frequencies are based on the IEEE 802.11a/g/p/n standards. If the frequency is changed arbitrarily to one that does not conform the standard, the simulation results could become inaccurate. Thus, no experiment for arbitrarily changing the signal frequency now.
- ◆ EstiNet X supports the configuration of several environmental parameters. Different part of these parameters are used by different channel models. Operating on channel models requires advanced professional knowledge. Now we do not step into such advanced field. The default channel model used on EstiNet X is a theoretical model, called two ray ground. There are two other theoretical models for choice - free space and free space shadowing. Now no experiment is designed for channel models.