

CSE421_Lab 02

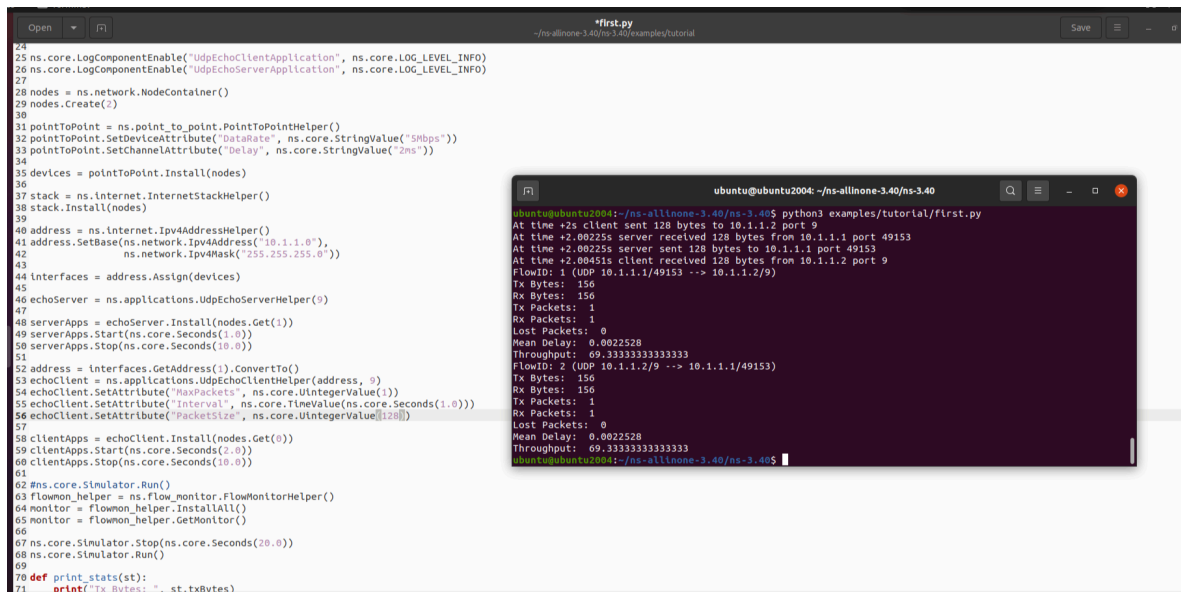
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Section: 10

Screenshots of Throughputs for different Packet sizes are given below:

1. Packet size: 128



```
25 ns.core.LogComponentEnable("UdpEchoClientApplication", ns.core.LOG_LEVEL_INFO)
26 ns.core.LogComponentEnable("UdpEchoServerApplication", ns.core.LOG_LEVEL_INFO)
27
28 nodes = ns.network.NodeContainer()
29 nodes.Create(2)
30
31 pointToPoint = ns.point_to_point.PointToPointHelper()
32 pointToPoint.SetDeviceAttribute("DataRate", ns.core.StringValue("5Mbps"))
33 pointToPoint.SetChannelAttribute("Delay", ns.core.StringValue("2ns"))
34
35 devices = pointToPoint.Install(nodes)
36
37 stack = ns.internet.InternetStackHelper()
38 stack.Install(nodes)
39
40 address = ns.internet.Ipv4AddressHelper()
41 address.SetBase(ns.network.Ipv4Address("10.1.1.0"),
42             ns.network.Ipv4Mask("255.255.255.0"))
43
44 interfaces = address.Assign(devices)
45
46 echoServer = ns.applications.UdpEchoServerHelper(9)
47
48 serverApps = echoServer.Install(nodes.Get(1))
49 serverApps.Start(ns.core.Seconds(1.0))
50 serverApps.Stop(ns.core.Seconds(10.0))
51
52 address = interfaces.GetAddress(1).ConvertTo()
53 echoClient = ns.applications.UdpEchoClientHelper(address, 9)
54 echoClient.SetAttribute("MaxPackets", ns.core.UintegerValue(1))
55 echoClient.SetAttribute("Interval", ns.core.TimeValue(ns.core.Seconds(1.0)))
56 echoClient.SetAttribute("PacketSize", ns.core.UintegerValue(128))
57
58 clientApps = echoClient.Install(nodes.Get(0))
59 clientApps.Start(ns.core.Seconds(1.0))
60 clientApps.Stop(ns.core.Seconds(10.0))
61
62 ns.core.Simulator.Run()
63 Flowmon_helper = ns.flow_monitor.FlowMonitorHelper()
64 monitor = flowmon_helper.InstallAll()
65 monitor = Flowmon_helper.GetMonitor()
66
67 ns.core.Simulator.Stop(ns.core.Seconds(20.0))
68 ns.core.Simulator.Run()
69
70 def print_stats(st):
71     print("Tx Bytes: ", st.txBytes)
```

```
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 128 bytes to 10.1.1.2 port 9
At time +2.00225s server received 128 bytes from 10.1.1.1 port 49153
At time +2.00225s server sent 128 bytes to 10.1.1.1 port 49153
At time +2.00451s client received 128 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 150
Rx Bytes: 150
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0022528
Throughput: 69.33333333333333
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 150
Rx Bytes: 150
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0022528
Throughput: 69.33333333333333
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$
```

Throughput: 69.3333

```
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 128 bytes to 10.1.1.2 port 9
At time +2.00225s server received 128 bytes from 10.1.1.1 port 49153
At time +2.00225s server sent 128 bytes to 10.1.1.1 port 49153
At time +2.00451s client received 128 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 150
Rx Bytes: 150
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0022528
Throughput: 69.33333333333333
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 150
Rx Bytes: 150
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0022528
Throughput: 69.33333333333333
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$
```

2. Packet size: 256

```
Open ▾ [ ] *first.py ~/ns-allinone-3.40/ns-3.40/examples/tutorial Save [≡] [x]
```

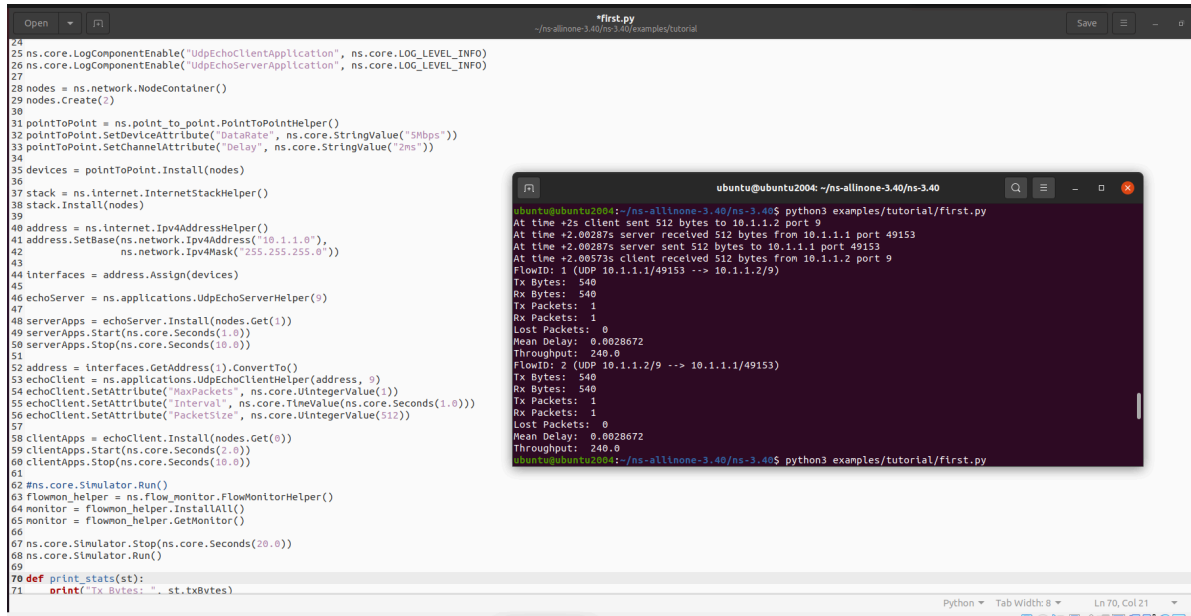
```
24
25 ns.core.LogComponentEnable("UdpEchoClientApplication", ns.core.LOG_LEVEL_INFO)
26 ns.core.LogComponentEnable("UdpEchoServerApplication", ns.core.LOG_LEVEL_INFO)
27
28 nodes = ns.network.NodeContainer()
29 nodes.Create(2)
30
31 pointToPoint = ns.point_to_point.PointToPointHelper()
32 pointToPoint.SetDeviceAttribute("DataRate", ns.core.StringValue("5Mbps"))
33 pointToPoint.SetChannelAttribute("Delay", ns.core.StringValue("2ms"))
34
35 devices = pointToPoint.Install(nodes)
36
37 stack = ns.internet.InternetStackHelper()
38 stack.Install(nodes)
39
40 address = ns.internet.Ipv4AddressHelper()
41 address.SetBase(ns.network.Ipv4Address("10.1.1.0"),
42               ns.network.Ipv4Mask("255.255.255.0"))
43
44 interfaces = address.Assign(devices)
45
46 echoServer = ns.applications.UdpEchoServerHelper(9)
47
48 serverApps = echoServer.Install(nodes.Get(1))
49 serverApps.Start(ns.core.Seconds(1.0))
50 serverApps.Stop(ns.core.Seconds(10.0))
51
52 address = interfaces.GetAddress(1).ConvertTo()
53 echoClient = ns.applications.UdpEchoClientHelper(address, 9)
54 echoClient.SetAttribute("MaxPackets", ns.core.UintegerValue(1))
55 echoClient.SetAttribute("Interval", ns.core.TimeValue(ns.core.Seconds(1.0)))
56 echoClient.SetAttribute("PacketSize", ns.core.UintegerValue(256))
57
58 clientApps = echoClient.Install(nodes.Get(0))
59 clientApps.Start(ns.core.Seconds(2.0))
60 clientApps.Stop(ns.core.Seconds(10.0))
61
62 #ns.core.Simulator.Run()
63 flowmon_helper = ns.flow_monitor.FlowMonitorHelper()
64 monitor = flowmon_helper.InstallAll()
65 monitor = flowmon_helper.GetMonitor()
66
67 ns.core.Simulator.Stop(ns.core.Seconds(20.0))
68 ns.core.Simulator.Run()
69
70 def print_stats(st):
71     print("Tx Bytes: ", st.txBytes)
```

```
ubuntu@ubuntu2004: ~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 256 bytes to 10.1.1.2 port 9
At time +2.00246s server received 256 bytes from 10.1.1.1 port 49153
At time +2.00246s server sent 256 bytes to 10.1.1.1 port 49153
At time +2.00492s client received 256 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 284
Rx Bytes: 1
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0024576
Throughput: 126.2222222222223
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 284
Rx Bytes: 1
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0024576
Throughput: 126.2222222222223
ubuntu@ubuntu2004: ~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
```

Throughput: 126.2223

```
ubuntu@ubuntu2004: ~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 256 bytes to 10.1.1.2 port 9
At time +2.00246s server received 256 bytes from 10.1.1.1 port 49153
At time +2.00246s server sent 256 bytes to 10.1.1.1 port 49153
At time +2.00492s client received 256 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 284
Rx Bytes: 1
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0024576
Throughput: 126.2222222222223
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 284
Rx Bytes: 1
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0024576
Throughput: 126.2222222222223
ubuntu@ubuntu2004: ~/ns-allinone-3.40/ns-3.40$
```

3. Packet size: 512



The screenshot shows a code editor with a Python script named `first.py` and a terminal window displaying the output of the script.

Python Script (`first.py`):

```
25 ns.core.LogComponentEnable("UdpEchoClientApplication", ns.core.LOG_LEVEL_INFO)
26 ns.core.LogComponentEnable("UdpEchoServerApplication", ns.core.LOG_LEVEL_INFO)
27
28 nodes = ns.network.NodeContainer()
29 nodes.Create(2)
30
31 pointToPoint = ns.point_to_point.PointToPointHelper()
32 pointToPoint.SetDeviceAttribute("DataRate", ns.core.StringValue("5Mbps"))
33 pointToPoint.SetChannelAttribute("Delay", ns.core.StringValue("2ns"))
34
35 devices = pointToPoint.Install(nodes)
36
37 stack = ns.Internet.InternetStackHelper()
38 stack.Install(nodes)
39
40 address = ns.Internet.Ipv4AddressHelper()
41 address.SetBase(ns.network.Ipv4Address("10.1.1.0"),
42             ns.network.Ipv4Mask("255.255.255.0"))
43
44 interfaces = address.Assign(devices)
45
46 echoServer = ns.applications.UdpEchoServerHelper(9)
47
48 serverApps = echoServer.Install(nodes.Get(1))
49 serverApps.Start(ns.core.Seconds(1.0))
50 serverApps.Stop(ns.core.Seconds(10.0))
51
52 address = interfaces.GetAddress(1).ConvertTo()
53 echoClient = ns.applications.UdpEchoClientHelper(address, 9)
54 echoClient.SetAttribute("MaxPackets", ns.core.UintegerValue(1))
55 echoClient.SetAttribute("Interval", ns.core.TimeValue(ns.core.Seconds(1.0)))
56 echoClient.SetAttribute("PacketSize", ns.core.UintegerValue(512))
57
58 clientApps = echoClient.Install(nodes.Get(0))
59 clientApps.Start(ns.core.Seconds(2.0))
60 clientApps.Stop(ns.core.Seconds(10.0))
61
62 #ns.core.Simulator.Run()
63 flowmon_helper = ns.Flow_monitor.FlowMonitorHelper()
64 monitor = flowmon_helper.InstallAll()
65 monitor = flowmon_helper.GetMonitor()
66
67 ns.core.Simulator.Stop(ns.core.Seconds(20.0))
68 ns.core.Simulator.Run()
69
70 def print_stats(st):
71     print("Tx Bytes: ", st.txBytes)
```

Terminal Output:

```
ubuntu@ubuntu2004: ~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 512 bytes to 10.1.1.2 port 9
At time +2.00287s server received 512 bytes from 10.1.1.1 port 49153
At time +2.00287s server sent 512 bytes to 10.1.1.1 port 49153
At time +2.00573s client received 512 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 540
Rx Bytes: 540
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0028672
Throughput: 240.0
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 540
Rx Bytes: 540
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0028672
Throughput: 240.0
ubuntu@ubuntu2004: ~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
```

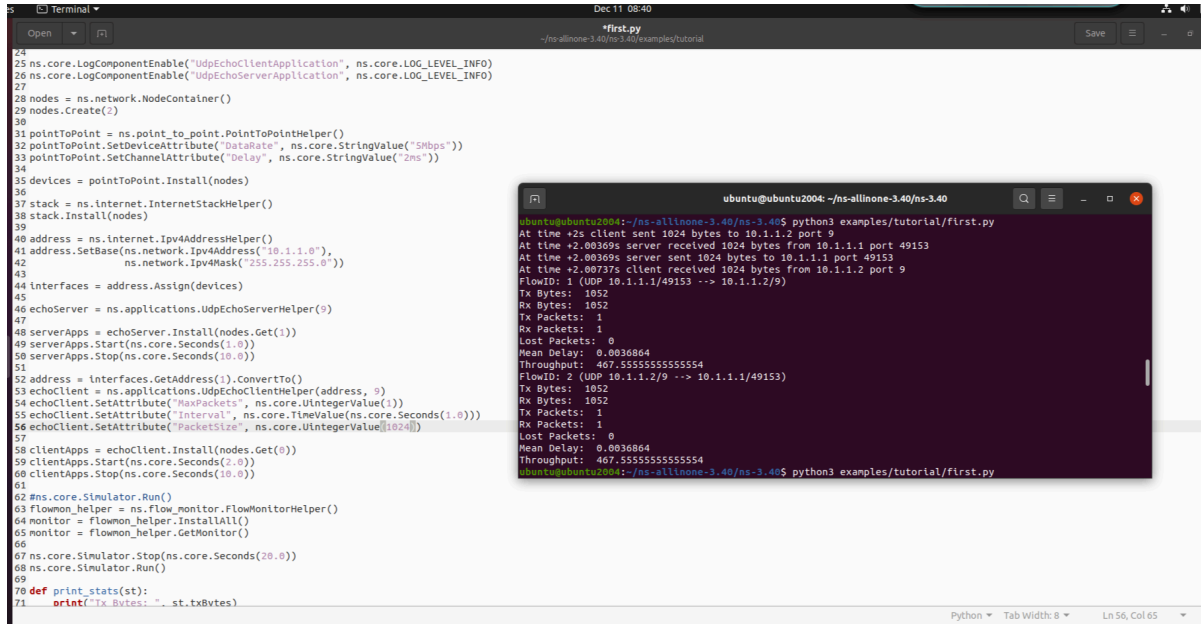
Throughput: 240.0



The screenshot shows a terminal window with the output of the network simulation script. The output displays the sequence of events, packet sizes, and performance metrics.

```
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 512 bytes to 10.1.1.2 port 9
At time +2.00287s server received 512 bytes from 10.1.1.1 port 49153
At time +2.00287s server sent 512 bytes to 10.1.1.1 port 49153
At time +2.00573s client received 512 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 540
Rx Bytes: 540
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0028672
Throughput: 240.0
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 540
Rx Bytes: 540
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0028672
Throughput: 240.0
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$
```

4. Packet size: 1024



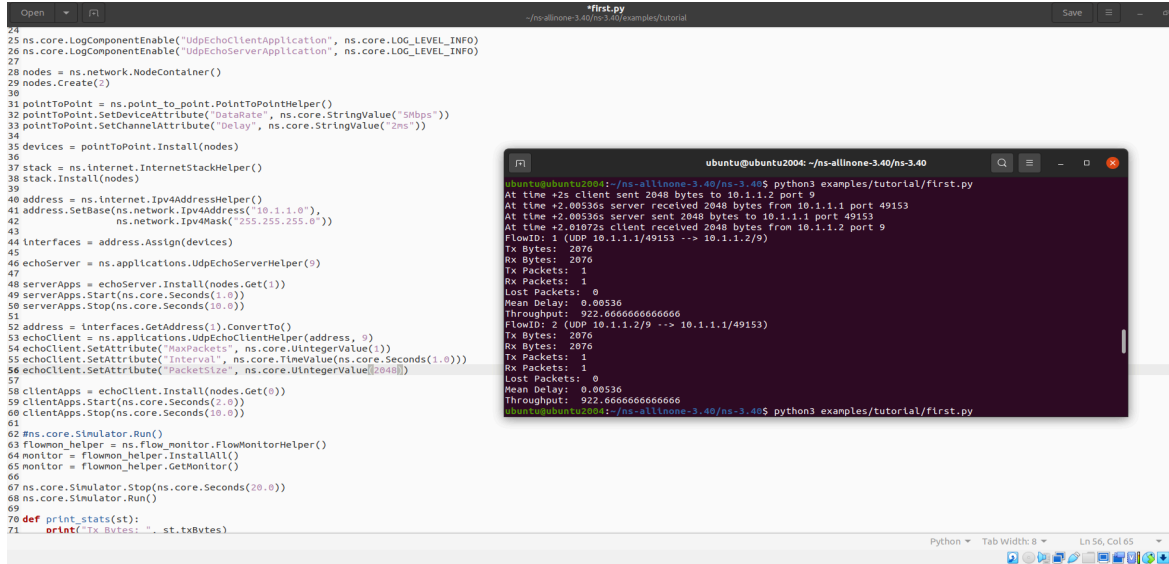
```
25 ns.core.LogComponentEnable("UdpEchoClientApplication", ns.core.LOG_LEVEL_INFO)
26 ns.core.LogComponentEnable("UdpEchoServerApplication", ns.core.LOG_LEVEL_INFO)
27
28 nodes = ns.network.NodeContainer()
29 nodes.Create(2)
30
31 pointToPoint = ns.point_to_point.PointToPointHelper()
32 pointToPoint.SetDeviceAttribute("DataRate", ns.core.StringValue("5Mbps"))
33 pointToPoint.SetChannelAttribute("Delay", ns.core.StringValue("2ms"))
34
35 devices = pointToPoint.Install(nodes)
36
37 stack = ns.internet.InternetStackHelper()
38 stack.Install(nodes)
39
40 address = ns.internet.Ipv4AddressHelper()
41 address.SetBase(ns.network.Ipv4Address("10.1.1.0"),
42               ns.network.Ipv4Mask("255.255.255.0"))
43
44 interfaces = address.Assign(devices)
45
46 echoServer = ns.applications.UdpEchoServerHelper(9)
47
48 serverApps = echoServer.Install(nodes.Get(1))
49 serverApps.Start(ns.core.Seconds(1.0))
50 serverApps.Stop(ns.core.Seconds(10.0))
51
52 address = interfaces.GetAddress(1).ConvertTo()
53 echoClient = ns.applications.UdpEchoClientHelper(address, 9)
54 echoClient.SetAttribute("MaxPackets", ns.core.IntegerValue(1))
55 echoClient.SetAttribute("Interval", ns.core.TimeValue(ns.core.Seconds(1.0)))
56 echoClient.SetAttribute("PacketsSize", ns.core.IntegerValue(1024))
57
58 clientApps = echoClient.Install(nodes.Get(0))
59 clientApps.Start(ns.core.Seconds(2.0))
60 clientApps.Stop(ns.core.Seconds(10.0))
61
62 mns.core.Simulator.Run()
63 flowmon_helper = ns.flow_monitor.FlowMonitorHelper()
64 monitor = flowmon_helper.InstallAll()
65 monitor = flowmon_helper.GetMonitor()
66
67 ns.core.Simulator.Stop(ns.core.Seconds(20.0))
68 ns.core.Simulator.Run()
69
70 def print_stats(st):
71     print("Tx Bytes: ", st.txBytes)
```

```
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 1024 bytes to 10.1.1.2 port 9
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 1052
Rx Bytes: 1052
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0036864
Throughput: 467.55555555555554
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 1052
Rx Bytes: 1052
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0036864
Throughput: 467.55555555555554
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
```

Throughput: 467.5554

```
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 1024 bytes to 10.1.1.2 port 9
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 1052
Rx Bytes: 1052
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0036864
Throughput: 467.55555555555554
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 1052
Rx Bytes: 1052
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.0036864
Throughput: 467.55555555555554
ubuntu@ubuntu2004:~/ns-allinone-3.40/ns-3.40$
```

5. Packet size: 2048




```
24
25 ns.core.LogComponentEnable("UdpEchoClientApplication", ns.core.LOG_LEVEL_INFO)
26 ns.core.LogComponentEnable("UdpEchoServerApplication", ns.core.LOG_LEVEL_INFO)
27
28 nodes = ns.network.NodeContainer()
29 nodes.Create(2)
30
31 pointToPoint = ns.point_to_point.PointToPointHelper()
32 pointToPoint.SetDeviceAttribute("DataRate", ns.core.StringValue("5Mbps"))
33 pointToPoint.SetChannelAttribute("Delay", ns.core.StringValue("2ns"))
34
35 devices = pointToPoint.Install(nodes)
36
37 stack = ns.internet.InternetStackHelper()
38 stack.Install(nodes)
39
40 address = ns.internet.Ipv4AddressHelper()
41 address.SetBase(ns.network.Ipv4Address("10.1.1.0"),
42 ns.network.Ipv4Mask("255.255.255.0"))
43
44 interfaces = address.Assign(devices)
45
46 echoServer = ns.applications.UdpEchoServerHelper(9)
47
48 serverApps = echoServer.Install(nodes.Get(1))
49 serverApps.Start(ns.core.Seconds(1.0))
50 serverApps.Stop(ns.core.Seconds(10.0))
51
52 address = interfaces.GetAddress(1).ConvertTo()
53 echoClient = ns.applications.UdpEchoClientHelper(address, 9)
54 echoClient.SetAttribute("MaxPackets", ns.core.UintegerValue(1))
55 echoClient.SetAttribute("Interval", ns.core.TimeValue(ns.core.Seconds(1.0)))
56 echoClient.SetAttribute("PacketSize", ns.core.UintegerValue(2048))
57
58 clientApps = echoClient.Install(nodes.Get(0))
59 clientApps.Start(ns.core.Seconds(2.0))
60 clientApps.Stop(ns.core.Seconds(10.0))
61
62 #ns.core.Simulator.Run()
63 flowmon_helper = ns.flow_monitor.FlowMonitorHelper()
64 monitor = flowmon_helper.InstallAll()
65 monitor = flowmon_helper.GetMonitor()
66
67 ns.core.Simulator.Stop(ns.core.Seconds(20.0))
68 ns.core.Simulator.Run()
69
70 def print_stats(st):
71     print("Tx Bytes: ", st.txBytes)
```

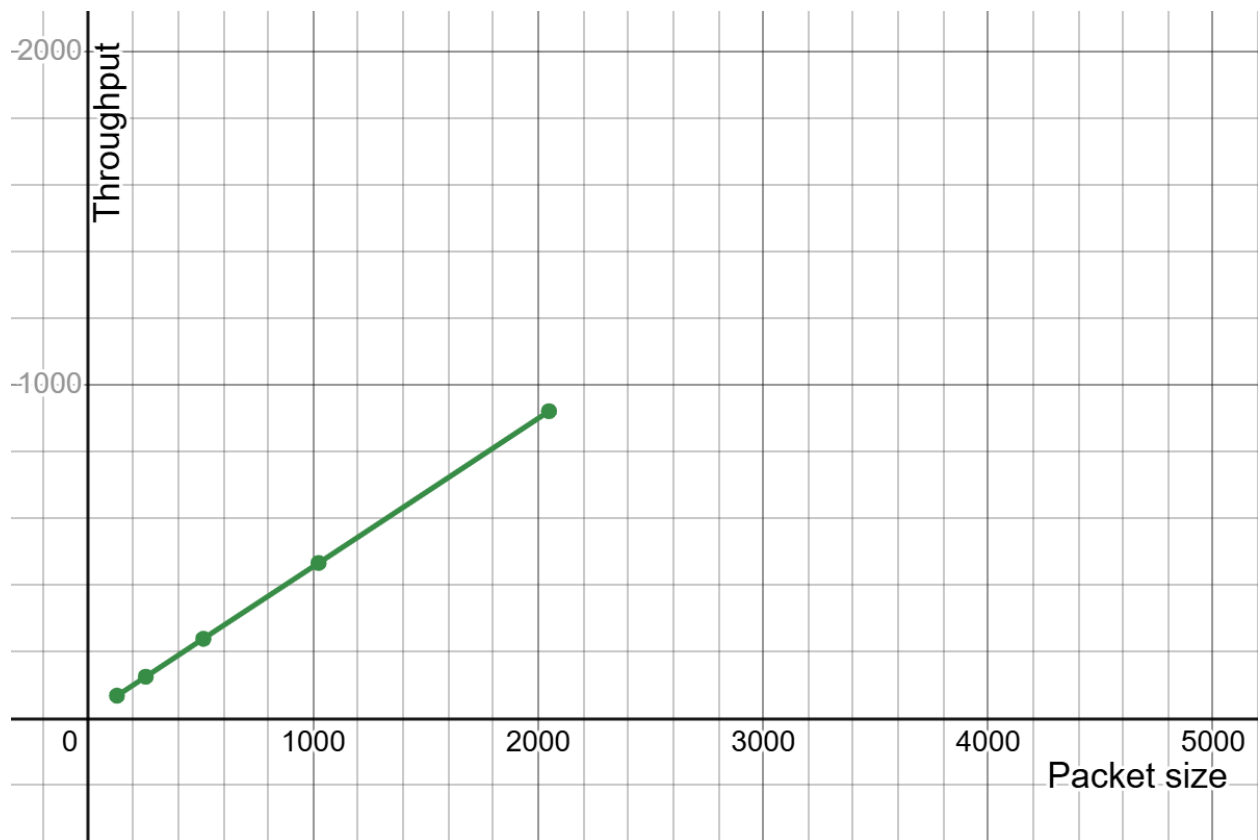
```
ubuntu@ubuntu2004:~/ns-allinone-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 2048 bytes to 10.1.1.2 port 9
At time +2.00536s server received 2048 bytes from 10.1.1.1 port 49153
At time +2.00536s server sent 2048 bytes to 10.1.1.1 port 49153
At time +2.01072s client received 2048 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 2076
Rx Bytes: 2076
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.00536
Throughput: 922.6666666666666
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 2076
Rx Bytes: 2076
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.00536
Throughput: 922.6666666666666
ubuntu@ubuntu2004:~/ns-allinone-3.40$ python3 examples/tutorial/first.py
```

Throughput: 922.6667

```
ubuntu@ubuntu2004:~/ns-allinone-3.40$ python3 examples/tutorial/first.py
At time +2s client sent 2048 bytes to 10.1.1.2 port 9
At time +2.00536s server received 2048 bytes from 10.1.1.1 port 49153
At time +2.00536s server sent 2048 bytes to 10.1.1.1 port 49153
At time +2.01072s client received 2048 bytes from 10.1.1.2 port 9
FlowID: 1 (UDP 10.1.1.1/49153 --> 10.1.1.2/9)
Tx Bytes: 2076
Rx Bytes: 2076
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.00536
Throughput: 922.6666666666666
FlowID: 2 (UDP 10.1.1.2/9 --> 10.1.1.1/49153)
Tx Bytes: 2076
Rx Bytes: 2076
Tx Packets: 1
Rx Packets: 1
Lost Packets: 0
Mean Delay: 0.00536
Throughput: 922.6666666666666
ubuntu@ubuntu2004:~/ns-allinone-3.40$
```

Graph: Throughput (y-axis) vs Packet size (x-axis)

x_1	 y_1	
128	69.3333	
256	126.2222	
512	240	
1024	467.5556	
2048	922.6667	



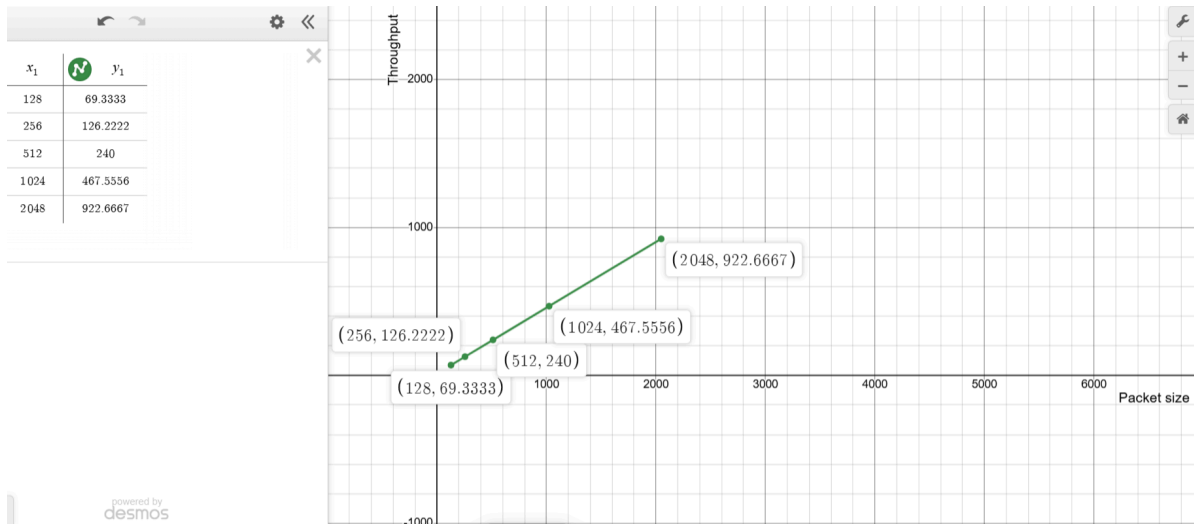


Figure: Throughput vs Packet size graph

If we plot packet size against throughput, we can see a straight line. The following graph shows that throughput is directly proportional to packet size. Therefore if we increase the packet size of our data, throughput will also increase proportionally.