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Network Laboratory

Programming Assignment-6

Ques:

TCP and router queues

- **Level**: Introductory
- **Expected learning outcome**: Queues, packet drops and their effect on congestion window size.
- **Experiment**:
  1. As in previous exercise, Create a simple dumbbell topology, two client Node1 and Node2 on the left side of the dumbbell and server nodes Node3 and Node4 on the right side of the dumbbell. Let Node5 and Node6 form the bridge of the dumbbell. Use point to point links.
  2. Add drop tail queues of size QueueSize5 and QueueSize6 to Node5 and Node6, respectively.
  3. Install a TCP socket instance on Node1 that will connect to Node3.
  4. Install a TCP socket instance on Node2 that will connect to Node3.
  5. Install a TCP socket instance on Node2 that will connect to Node4.
  6. Start Node1--Node3 flow at time 1s, then measure it's throughput. How long does it take to fill link's entire capacity?
  7. Start Node2--Node3 and Node2--Node4 flows at time 15s, measure their throughput.
  8. Measure packet loss and cwnd size, and plot graphs throughput/time, cwnd/time and packet loss/time for each of the flows.
  9. Plot graph throughput/cwnd and packet loss/cwnd for the first flow. Is there an optimal value for cwnd?
  10. Vary QueueSize5 and QueueSize6. Which one has immediate effect on cwnd size of the first flow? Explain why.

Source Code

ques3.cc

```
#include "ns3/applications-module.h"
#include "ns3/core-module.h"
#include "ns3/flow-monitor-module.h"
#include "ns3/internet-module.h"
#include "ns3/ipv4-global-routing-helper.h"
#include "ns3/network-module.h"
#include "ns3/point-to-point-module.h"
#include <fstream>
#include <string>

using namespace ns3;

NS_LOG_COMPONENT_DEFINE("Lab3");

class MyApp : public Application
{
 public:
   MyApp();
   virtual ~MyApp();

   void Setup(Ptr<Socket> socket,
              Address address,
              uint32_t packetSize,
              uint32_t nPackets,
              DataRate dataRate);
   void ChangeRate(DataRate newrate);

 private:
   virtual void StartApplication(void);
   virtual void StopApplication(void);
```

```
    void ScheduleTx(void);
    void SendPacket(void);

    Ptr<Socket> m_socket;
    Address m_peer;
    uint32_t m_packetSize;
    uint32_t m_nPackets;
    DataRate m_dataRate;
    EventId m_sendEvent;
    bool m_running;
    uint32_t m_packetsSent;
};

MyApp::MyApp()
    : m_socket(0),
      m_peer(),
      m_packetSize(0),
      m_nPackets(0),
      m_dataRate(0),
      m_sendEvent(),
      m_running(false),
      m_packetsSent(0)
{
}

MyApp::~MyApp()
{
    m_socket = 0;
}

void
MyApp::Setup(Ptr<Socket> socket,
             Address address,
             uint32_t packetSize,
             uint32_t nPackets,
             DataRate dataRate)
{
    m_socket = socket;
    m_peer = address;
    m_packetSize = packetSize;
    m_nPackets = nPackets;
    m_dataRate = dataRate;
}

void
MyApp::StartApplication(void)
{
    m_running = true;
    m_packetsSent = 0;
    m_socket->Bind();
    m_socket->Connect(m_peer);
    SendPacket();
}

void
MyApp::StopApplication(void)
{
    m_running = false;
```

```
    if (m_sendEvent.IsRunning())
    {
        Simulator::Cancel(m_sendEvent);
    }

    if (m_socket)
    {
        m_socket->Close();
    }
}

void
MyApp::SendPacket(void)
{
    Ptr<Packet> packet = Create<Packet>(m_packetSize);
    m_socket->Send(packet);

    if (++m_packetsSent < m_nPackets)
    {
        ScheduleTx();
    }
}

void
MyApp::ScheduleTx(void)
{
    if (m_running)
    {
        Time tNext(Seconds(m_packetSize * 8 /
static_cast<double>(m_dataRate.GetBitRate())));
        m_sendEvent = Simulator::Schedule(tNext, &MyApp::SendPacket, this);
    }
}

void
MyApp::ChangeRate(DataRate newrate)
{
    m_dataRate = newrate;
    return;
}

static void
CwndChange(uint32_t oldCwnd, uint32_t newCwnd)
{
    std::cout << Simulator::Now().GetSeconds() << "\t" << newCwnd << "\n";
}

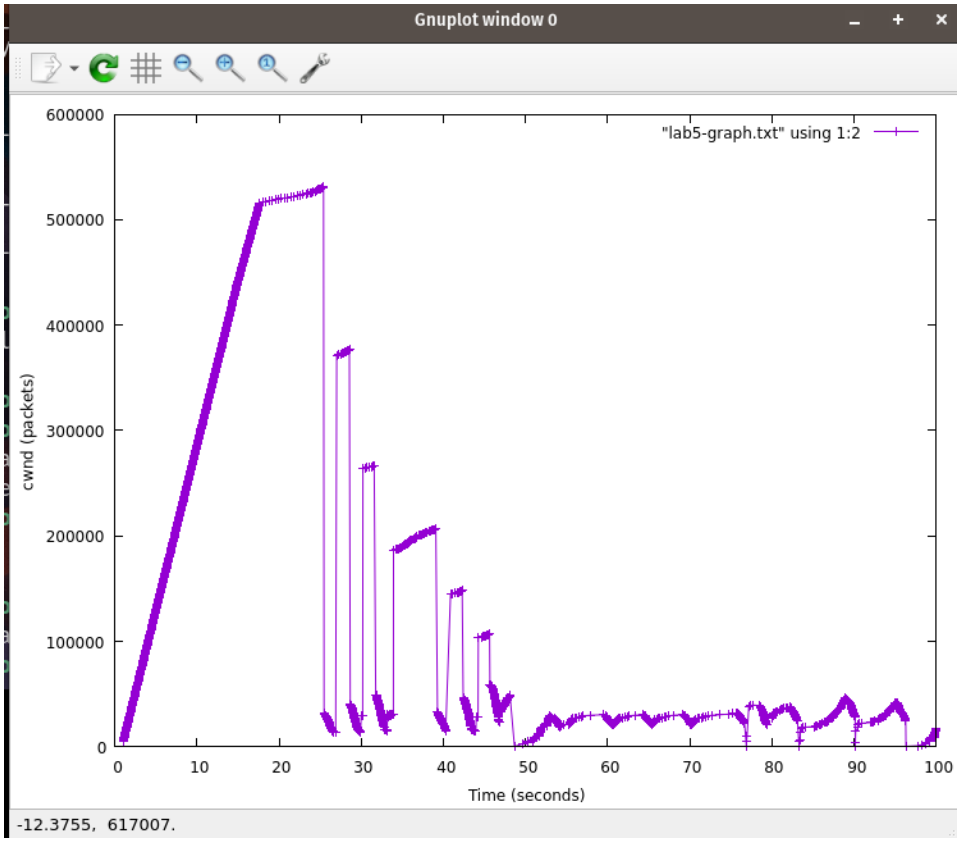
void
IncRate(Ptr<MyApp> app, DataRate rate)
{
    app->ChangeRate(rate);
    return;
}

int
main(int argc, char* argv[])
{
    std::string lat = "2ms";
```

```
    std::string rate = "500kb/s";
    bool enableFlowMonitor = false;
    CommandLine cmd;
    cmd.AddValue("latency", "P2P link Latency in miliseconds", lat);
    cmd.AddValue("rate", "P2P data rate in bps", rate);
    cmd.AddValue("EnableMonitor", "Enable Flow Monitor", enableFlowMonitor);
    cmd.Parse(argc, argv);
    NS_LOG_INFO("Create nodes.");
    NodeContainer c;
    c.Create(6);
    NodeContainer n0n4 = NodeContainer(c.Get(0), c.Get(4));
    NodeContainer n1n4 = NodeContainer(c.Get(1), c.Get(4));
    NodeContainer n2n5 = NodeContainer(c.Get(2), c.Get(5));
    NodeContainer n3n5 = NodeContainer(c.Get(3), c.Get(5));
    NodeContainer n4n5 = NodeContainer(c.Get(4), c.Get(5));
    InternetStackHelper internet;
    internet.Install(c);
    NS_LOG_INFO("Create channels.");
    PointToPointHelper p2p;
    p2p.SetDeviceAttribute("DataRate", StringValue(rate));
    p2p.SetChannelAttribute("Delay", StringValue(lat));
    NetDeviceContainer d0d4 = p2p.Install(n0n4);
    NetDeviceContainer d1d4 = p2p.Install(n1n4);
    NetDeviceContainer d4d5 = p2p.Install(n4n5);
    NetDeviceContainer d2d5 = p2p.Install(n2n5);
    NetDeviceContainer d3d5 = p2p.Install(n3n5);
    NS_LOG_INFO("Assign IP Addresses.");
    Ipv4AddressHelper ipv4;
    ipv4.SetBase("12.12.1.0", "255.255.255.0");
    Ipv4InterfaceContainer i0i4 = ipv4.Assign(d0d4);
    ipv4.SetBase("12.12.2.0", "255.255.255.0");
    Ipv4InterfaceContainer i1i4 = ipv4.Assign(d1d4);
    ipv4.SetBase("12.12.3.0", "255.255.255.0");
    Ipv4InterfaceContainer i4i5 = ipv4.Assign(d4d5);
    ipv4.SetBase("12.12.4.0", "255.255.255.0");
    Ipv4InterfaceContainer i2i5 = ipv4.Assign(d2d5);
    ipv4.SetBase("12.12.5.0", "255.255.255.0");
    Ipv4InterfaceContainer i3i5 = ipv4.Assign(d3d5);
    NS_LOG_INFO("Enable static global routing.");
    Ipv4GlobalRoutingHelper::PopulateRoutingTables();
    NS_LOG_INFO("Create Applications.");
    uint16_t sinkPort = 8080;
    Address sinkAddress(InetSocketAddress(i2i5.GetAddress(0), sinkPort));
    PacketSinkHelper packetSinkHelper("ns3::TcpSocketFactory",
                                      InetSocketAddress(Ipv4Address::GetAny(), sinkPort));
    ApplicationContainer sinkApps = packetSinkHelper.Install(c.Get(2));
    sinkApps.Start(Seconds(0.));
    sinkApps.Stop(Seconds(100.));
    Ptr<Socket> ns3TcpSocket =
       Socket::CreateSocket(c.Get(0), TcpSocketFactory::GetTypeId());
    ns3TcpSocket->TraceConnectWithoutContext("CongestionWindow",
MakeCallback(&CwndChange));
    Ptr<MyApp> app = CreateObject<MyApp>();
    app->Setup(ns3TcpSocket, sinkAddress, 1040, 100000, DataRate("250Kbps"));
    c.Get(0)->AddApplication(app);
    app->SetStartTime(Seconds(1.));
    app->SetStopTime(Seconds(100.));
    uint16_t sinkPort2 = 6;
    Address sinkAddress2(InetSocketAddress(i3i5.GetAddress(0), sinkPort2));
```

```
    PacketSinkHelper packetSinkHelper2("ns3::TcpSocketFactory",
                                       InetSocketAddress(Ipv4Address::GetAny(), sinkPort2));
    ApplicationContainer sinkApps2 = packetSinkHelper2.Install(c.Get(3));
    sinkApps2.Start(Seconds(0.));
    sinkApps2.Stop(Seconds(100.));
    ns3TcpSocket = Socket::CreateSocket(c.Get(1), TcpSocketFactory::GetTypeId());
    Ptr<MyApp> app2 = CreateObject<MyApp>();
    app2->Setup(ns3TcpSocket, sinkAddress2, 1040, 100000, DataRate("250Kbps"));
    c.Get(1)->AddApplication(app2);
    app2->SetStartTime(Seconds(15.));
    app2->SetStopTime(Seconds(100.));
    Simulator::Schedule(Seconds(30.0), &IncRate, app2, DataRate("500kbps"));
    Ptr<FlowMonitor> flowmon;
    if (enableFlowMonitor)
    {
       FlowMonitorHelper flowmonHelper;
       flowmon = flowmonHelper.InstallAll();
    }
    NS_LOG_INFO("Run Simulation.");
    Simulator::Stop(Seconds(100.0));
    Simulator::Run();
    if (enableFlowMonitor)
    {
       flowmon->CheckForLostPackets();
       flowmon->SerializeToXmlFile("lab-3.flowmon", true, true);
    }
    Simulator::Destroy();
    NS_LOG_INFO("Done.");
}
```

Gnu Plot:



Terminal:

```
emperor-kautilya@pop-os:~/Programs/ns-allinone-3.37/ns-3.37$ ./ns3 run q3.cc
Consolidate compiler generated dependencies of target scratch_lab5
[  0%] Building CXX object scratch/CMakeFiles/scratch_lab5.dir/lab5.cc.o
[  0%] Linking CXX executable ../../build/scratch/ns3.37-lab5-default
1.01757 5360
1.06134 5896
1.07971 6432
1.10947 7504
1.14275 8576
1.17603 9648
1.20931 10720
1.24259 11792
1.27587 12864
1.30915 13936
1.34243 15008
1.37571 16080
1.40899 17152
1.44227 18224
1.47555 19296
1.50883 20368
1.54211 21440
1.57539 22512
1.60867 23048
1.64195 24120
1.67523 25192
1.70851 26264
1.74179 27336
1.77507 28408
1.80835 29480
1.84163 30552
1.87491 31624
1.90819 32696
1.94147 33768
1.97475 34840
2.00803 35912
2.04131 36984
2.07459 38056
2.10787 39128
2.14115 40200
2.17443 40736
2.20771 41808
2.24099 42880
2.27427 43952
2.30755 45024
2.34083 46096
2.37411 47168
2.40739 48240
2.44067 49312
2.47395 50384
2.50723 51456
2.54051 52528
2.57379 53600
2.60707 54672
2.64035 55744
2.67363 56816
2.70691 57888
2.74019 58424
2.77347 59496
2.80675 60568
2.84003 61640
```

2.87331 62712
2.90659 63784
2.93987 64856
2.97315 65928
3.00643 67000
3.03971 68072
3.07299 69144
3.10627 70216
3.13955 71288
3.17283 72360
3.20611 73432
3.23939 74504
3.27267 75576
3.30595 76112
3.33923 77184
3.37251 78256
3.40579 79328
3.43907 80400
3.47235 81472
3.50563 82544
3.53891 83616
3.57219 84688
3.60547 85760
3.63875 86832
3.67203 87904
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3.73859 90048
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4.07139 100232
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4.13795 102376
4.17123 103448
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4.23779 105592
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4.30435 107736
4.33763 108808
4.37091 109880
4.40419 110416
4.43747 111488
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4.50403 113632
4.53731 114704
4.57059 115776
4.60387 116848
4.63715 117920
4.67043 118992
4.70371 120064
4.73699 121136
4.77027 122208
4.80355 123280
4.83683 124352
4.87011 125424
4.90339 126496
4.93667 127568
4.96995 128104

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5.43587 143112
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5.53571 145792
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5.63555 149008
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5.83523 155440
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5.90179 157584
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6.23459 167768
6.26787 168840
6.30115 169912
6.33443 170984
6.36771 172056
6.40099 173128
6.43427 174200
6.46755 175272
6.50083 176344
6.53411 177416
6.56739 178488
6.60067 179560
6.63395 180096
6.66723 181168
6.70051 182240
6.73379 183312
6.76707 184384
6.80035 185456
6.83363 186528
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6.90019 188672
6.93347 189744
6.96675 190816
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7.13315 196176
7.16643 197248
7.19971 197784
7.23299 198856
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7.29955 201000
7.33283 202072
7.36611 203144
7.39939 204216
7.43267 205288
7.46595 206360
7.49923 207432
7.53251 208504
7.56579 209576
7.59907 210648
7.63235 211720
7.66563 212792
7.69891 213864
7.73219 214936
7.76547 215472
7.79875 216544
7.83203 217616
7.86531 218688
7.89859 219760
7.93187 220832
7.96515 221904
7.99843 222976
8.03171 224048
8.06499 225120
8.09827 226192
8.13155 227264
8.16483 228336
8.19811 229408
8.23139 230480
8.26467 231552
8.29795 232088
8.33123 233160
8.36451 234232
8.39779 235304
8.43107 236376
8.46435 237448
8.49763 238520
8.53091 239592
8.56419 240664
8.59747 241736
8.63075 242808
8.66403 243880
8.69731 244952
8.73059 246024
8.76387 247096
8.79715 248168
8.83043 249240
8.86371 249776
8.89699 250848
8.93027 251920
8.96355 252992
8.99683 254064
9.03011 255136
9.06339 256208
9.09667 257280
9.12995 258352
9.16323 259424
9.19651 260496
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16.7629 491512
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26.3884 17432
26.4067 16928
26.4429 16424
26.4802 15920
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26.5264 14944
26.5452 14912
26.5919 14408
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27.6654 373056
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28.3313 375736
28.4415 376272
28.57   376808
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28.6806 40528
28.6901 40024
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28.8194 37976
28.8289 37944
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95.7785 32915
95.7879 32743
95.7974 32571
95.8351 32399
95.8446 32227
95.8823 32055
95.8918 31883
95.9012 31711
95.9295 31538
95.939  31366
95.9484 31194
95.9579 30486
95.9673 29480
96.0334 28944
96.0428 28408
96.1183 27872
96.1278 27336
96.1372 26800
96.175  26264
96.2222 25192
96.2694 24656
96.2973 536
97.7426 1072
98.1845 2144
98.6471 3216
98.6849 4288
99.1474 5360
99.1852 6432
99.2229 7504
99.2607 8576
99.7233 9648
99.7516 10720
99.7893 11792
99.8082 12864
99.846  13936
99.8649 15008
99.9026 16080
99.9309 17152
emperor-kautilya@pop-os:~/Programs/ns-allinone-3.37/ns-3.37$ ./ns3 run lab5.cc
>> lab5-graph.txt
emperor-kautilya@pop-os:~/Programs/ns-allinone-3.37/ns-3.37$ gedit lab5-
graph.txt
emperor-kautilya@pop-os:~/Programs/ns-allinone-3.37/ns-3.37$ gnuplot
```

```
        G N U P L O T
        Version 5.4 patchlevel 2    last modified 2021-06-01

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        Thomas Williams, Colin Kelley and many others

        gnuplot home:     http://www.gnuplot.info
        faq, bugs, etc:   type "help FAQ"
        immediate help:   type "help"  (plot window: hit &apos;h&apos;)

Terminal type is now &apos;qt&apos;
gnuplot> set style line 1 lc rgb &apos;#0060ad&apos; lt 1 lw 2 pt 7 ps 1.5
gnuplot> plot "lab5-graph.txt"
gnuplot>
```