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Lab Report

Department of Information and Communication Technology

Report No: 03
Report Name: TCP and router queues.

Course Title: Wireless and Mobile Communication Lab.
Course Code: ICT-4202

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Experiment N0: 03
Name of Experiments: TCP and Router Queues.

Objectives:

1. 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. Install a TCP socket instance on Node1 that will connect to Node3.
3. Install a UDP socket instance on Node2 that will connect to Node4.
4. Start the TCP application at time 1s.
5. Start the UDP application at time 20s at rate Rate1 such that it clogs half the dumbbell bridge's link capacity.
6. Increase the UDP application's rate at time 30s to rate Rate2 such that it clogs the whole of the dumbbell bridge's capacity.
7. Use the ns-3 tracing mechanism to record changes in congestion window size of the TCP instance over time. Use gnuplot/matplotlib to visualize plots of cwnd vs time.
8. Mark points of fast recovery and slow start in the graphs.
9. Perform the above experiment for TCP variants Tahoe, Reno and New Reno, all of which are available with ns-3.

Source Code:

```
/* -*- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil; -*- */
 /*
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  *
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  * it under the terms of the GNU General Public License version 2 as
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```
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 *
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 */

// This example serves as a benchmark for all the queue discs (with BQL enabled or not)
//
// Network topology
//
//              192.168.1.0                    192.168.2.0
// n1 ----------------------------------- n2 ----------------------------------- n3
//   point-to-point (access link)            point-to-point (bottleneck link)
//   100 Mbps, 0.1 ms                      bandwidth [10 Mbps], delay [5 ms]
//   qdiscs PfifoFast with capacity          qdiscs queueDiscType in {PfifoFast, ARED, CoDel, FqCoDel, PIE} [PfifoFast]
//   of 1000 packets                       with capacity of queueDiscSize packets [1000]
//       netdevices queues with size of 100 packets   netdevices queues with size of netdevicesQueueSize packets [100]
//   without BQL                           bql BQL [false]
//   *** fixed configuration ***
//
// Two TCP flows are generated: one from n1 to n3 and the other from n3 to n1.
// Additionally, n1 pings n3, so that the RTT can be measured.
//
// The output will consist of a number of ping Rtt such as:
//
```

```
//    /NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
//    /NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
//    /NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
//    /NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
//    /NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
//    /NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms
//    /NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/internet-apps-module.h"
#include "ns3/traffic-control-module.h"
#include "ns3/flow-monitor-module.h"

using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("BenchmarkQueueDiscs");

void
LimitsTrace (Ptr<OutputStreamWrapper> stream, uint32_t oldVal, uint32_t newVal)
{
  *stream->GetStream () << Simulator::Now ().GetSeconds () << " " << newVal << std::endl;
}

void
BytesInQueueTrace (Ptr<OutputStreamWrapper> stream, uint32_t oldVal, uint32_t newVal)
{
  *stream->GetStream () << Simulator::Now ().GetSeconds () << " " << newVal << std::endl;
```

```
}

static void
GoodputSampling (std::string fileName, ApplicationContainer app, Ptr<OutputStreamWrapper>
stream, float period)
{
  Simulator::Schedule (Seconds (period), &GoodputSampling, fileName, app, stream, period);
  double goodput;
  uint64_t totalPackets = DynamicCast<PacketSink> (app.Get (0))->GetTotalRx ();
  goodput = totalPackets * 8 / (Simulator::Now ().GetSeconds () * 1024); // Kbit/s
  *stream->GetStream () << Simulator::Now ().GetSeconds () << " " << goodput << std::endl;
}

static void PingRtt (std::string context, Time rtt)
{
  std::cout << context << "=" << rtt.GetMilliSeconds () << " ms" << std::endl;
}

int main (int argc, char *argv[])
{
  std::string bandwidth = "10Mbps";
  std::string delay = "5ms";
  std::string queueDiscType = "PfifoFast";
  uint32_t queueDiscSize = 1000;
  uint32_t netdevicesQueueSize = 50;
  bool bql = false;

  std::string flowsDatarate = "20Mbps";
  uint32_t flowsPacketsSize = 1000;

  float startTime = 0.1f; // in s
```

```
  float simDuration = 60;
  float samplingPeriod = 1;

  CommandLine cmd (__FILE__);
  cmd.AddValue ("bandwidth", "Bottleneck bandwidth", bandwidth);
  cmd.AddValue ("delay", "Bottleneck delay", delay);
  cmd.AddValue ("queueDiscType", "Bottleneck queue disc type in {PfifoFast, ARED, CoDel, FqCoDel, PIE, prio}", queueDiscType);
  cmd.AddValue ("queueDiscSize", "Bottleneck queue disc size in packets", queueDiscSize);
  cmd.AddValue ("netdevicesQueueSize", "Bottleneck netdevices queue size in packets", netdevicesQueueSize);
  cmd.AddValue ("bql", "Enable byte queue limits on bottleneck netdevices", bql);
  cmd.AddValue ("flowsDatarate", "Upload and download flows datarate", flowsDatarate);
  cmd.AddValue ("flowsPacketsSize", "Upload and download flows packets sizes", flowsPacketsSize);
  cmd.AddValue ("startTime", "Simulation start time", startTime);
  cmd.AddValue ("simDuration", "Simulation duration in seconds", simDuration);
  cmd.AddValue ("samplingPeriod", "Goodput sampling period in seconds", samplingPeriod);
  cmd.Parse (argc, argv);

  float stopTime = startTime + simDuration;

  // Create nodes
  NodeContainer n1, n2, n3;
  n1.Create (1);
  n2.Create (1);
  n3.Create (1);

  // Create and configure access link and bottleneck link
  PointToPointHelper accessLink;
  accessLink.SetDeviceAttribute ("DataRate", StringValue ("100Mbps"));
```

```
  accessLink.SetChannelAttribute ("Delay", StringValue ("0.1ms"));
  accessLink.SetQueue ("ns3::DropTailQueue", "MaxSize", StringValue ("100p"));

  PointToPointHelper bottleneckLink;
  bottleneckLink.SetDeviceAttribute ("DataRate", StringValue (bandwidth));
  bottleneckLink.SetChannelAttribute ("Delay", StringValue (delay));
  bottleneckLink.SetQueue ("ns3::DropTailQueue", "MaxSize", StringValue (std::to_string
(netdevicesQueueSize) + "p"));

  InternetStackHelper stack;
  stack.InstallAll ();

  // Access link traffic control configuration
  TrafficControlHelper tchPfifoFastAccess;
  tchPfifoFastAccess.SetRootQueueDisc ("ns3::PfifoFastQueueDisc", "MaxSize", StringValue
("1000p"));

  // Bottleneck link traffic control configuration
  TrafficControlHelper tchBottleneck;

  if (queueDiscType.compare ("PfifoFast") == 0)
    {
      tchBottleneck.SetRootQueueDisc ("ns3::PfifoFastQueueDisc", "MaxSize",
                                      QueueSizeValue (QueueSize (QueueSizeUnit::PACKETS,
queueDiscSize)));
    }
  else if (queueDiscType.compare ("ARED") == 0)
    {
      tchBottleneck.SetRootQueueDisc ("ns3::RedQueueDisc");
      Config::SetDefault ("ns3::RedQueueDisc::ARED", BooleanValue (true));
      Config::SetDefault ("ns3::RedQueueDisc::MaxSize",
```

```
                QueueSizeValue (QueueSize (QueueSizeUnit::PACKETS, queueDiscSize)));
    }
  else if (queueDiscType.compare ("CoDel") == 0)
    {
      tchBottleneck.SetRootQueueDisc ("ns3::CoDelQueueDisc");
      Config::SetDefault ("ns3::CoDelQueueDisc::MaxSize",
                QueueSizeValue (QueueSize (QueueSizeUnit::PACKETS, queueDiscSize)));
    }
  else if (queueDiscType.compare ("FqCoDel") == 0)
    {
      tchBottleneck.SetRootQueueDisc ("ns3::FqCoDelQueueDisc");
      Config::SetDefault ("ns3::FqCoDelQueueDisc::MaxSize",
                QueueSizeValue (QueueSize (QueueSizeUnit::PACKETS, queueDiscSize)));
    }
  else if (queueDiscType.compare ("PIE") == 0)
    {
      tchBottleneck.SetRootQueueDisc ("ns3::PieQueueDisc");
      Config::SetDefault ("ns3::PieQueueDisc::MaxSize",
                QueueSizeValue (QueueSize (QueueSizeUnit::PACKETS, queueDiscSize)));
    }
  else if (queueDiscType.compare ("prio") == 0)
    {
      uint16_t handle = tchBottleneck.SetRootQueueDisc ("ns3::PrioQueueDisc", "Priomap",
                                        StringValue ("0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1"));
      TrafficControlHelper::ClassIdList cid = tchBottleneck.AddQueueDiscClasses (handle, 2,
"ns3::QueueDiscClass");
      tchBottleneck.AddChildQueueDisc (handle, cid[0], "ns3::FifoQueueDisc");
      tchBottleneck.AddChildQueueDisc (handle, cid[1], "ns3::RedQueueDisc");
    }
  else
    {
```

```
    NS_ABORT_MSG ("--queueDiscType not valid");
   }

  if (bql)
   {
    tchBottleneck.SetQueueLimits ("ns3::DynamicQueueLimits");
   }

  NetDeviceContainer devicesAccessLink = accessLink.Install (n1.Get (0), n2.Get (0));
  tchPfifoFastAccess.Install (devicesAccessLink);
  Ipv4AddressHelper address;
  address.SetBase ("192.168.0.0", "255.255.255.0");
  address.NewNetwork ();
  Ipv4InterfaceContainer interfacesAccess = address.Assign (devicesAccessLink);

  NetDeviceContainer devicesBottleneckLink = bottleneckLink.Install (n2.Get (0), n3.Get (0));
  QueueDiscContainer qdiscs;
  qdiscs = tchBottleneck.Install (devicesBottleneckLink);

  address.NewNetwork ();
  Ipv4InterfaceContainer interfacesBottleneck = address.Assign (devicesBottleneckLink);

  Ptr<NetDeviceQueueInterface> interface = devicesBottleneckLink.Get (0)->GetObject<NetDeviceQueueInterface> ();
  Ptr<NetDeviceQueue> queueInterface = interface->GetTxQueue (0);
  Ptr<DynamicQueueLimits> queueLimits = StaticCast<DynamicQueueLimits> (queueInterface->GetQueueLimits ());

  AsciiTraceHelper ascii;
  if (bql)
   {
```

```
    queueDiscType = queueDiscType + "-bql";
    Ptr<OutputStreamWrapper> streamLimits = ascii.CreateFileStream (queueDiscType + "-limits.txt");
    queueLimits->TraceConnectWithoutContext ("Limit",MakeBoundCallback (&LimitsTrace, streamLimits));
  }
 Ptr<Queue<Packet> > queue = StaticCast<PointToPointNetDevice> (devicesBottleneckLink.Get (0))->GetQueue ();
 Ptr<OutputStreamWrapper> streamBytesInQueue = ascii.CreateFileStream (queueDiscType + "-bytesInQueue.txt");
 queue->TraceConnectWithoutContext ("BytesInQueue",MakeBoundCallback (&BytesInQueueTrace, streamBytesInQueue));

 Ipv4InterfaceContainer n1Interface;
 n1Interface.Add (interfacesAccess.Get (0));

 Ipv4InterfaceContainer n3Interface;
 n3Interface.Add (interfacesBottleneck.Get (1));

 Ipv4GlobalRoutingHelper::PopulateRoutingTables ();

 Config::SetDefault ("ns3::TcpSocket::SegmentSize", UintegerValue (flowsPacketsSize));

 // Flows configuration
 // Bidirectional TCP streams with ping like flent tcp_bidirectional test.
 uint16_t port = 7;
 ApplicationContainer uploadApp, downloadApp, sourceApps;
 // Configure and install upload flow
 Address addUp (InetSocketAddress (Ipv4Address::GetAny (), port));
 PacketSinkHelper sinkHelperUp ("ns3::TcpSocketFactory", addUp);
 sinkHelperUp.SetAttribute ("Protocol", TypeIdValue (TcpSocketFactory::GetTypeId ()));
 uploadApp.Add (sinkHelperUp.Install (n3));
```

```
  InetSocketAddress socketAddressUp = InetSocketAddress (n3Interface.GetAddress (0), port);
  OnOffHelper onOffHelperUp ("ns3::TcpSocketFactory", Address ());
  onOffHelperUp.SetAttribute ("Remote", AddressValue (socketAddressUp));
  onOffHelperUp.SetAttribute ("OnTime", StringValue ("ns3::ConstantRandomVariable[Constant=1]"));
  onOffHelperUp.SetAttribute ("OffTime", StringValue ("ns3::ConstantRandomVariable[Constant=0]"));
  onOffHelperUp.SetAttribute ("PacketSize", UintegerValue (flowsPacketsSize));
  onOffHelperUp.SetAttribute ("DataRate", StringValue (flowsDatarate));
  sourceApps.Add (onOffHelperUp.Install (n1));

  port = 8;
  // Configure and install download flow
  Address addDown (InetSocketAddress (Ipv4Address::GetAny (), port));
  PacketSinkHelper sinkHelperDown ("ns3::TcpSocketFactory", addDown);
  sinkHelperDown.SetAttribute ("Protocol", TypeIdValue (TcpSocketFactory::GetTypeId ()));
  downloadApp.Add (sinkHelperDown.Install (n1));

  InetSocketAddress socketAddressDown = InetSocketAddress (n1Interface.GetAddress (0), port);
  OnOffHelper onOffHelperDown ("ns3::TcpSocketFactory", Address ());
  onOffHelperDown.SetAttribute ("Remote", AddressValue (socketAddressDown));
  onOffHelperDown.SetAttribute ("OnTime", StringValue ("ns3::ConstantRandomVariable[Constant=1]"));
  onOffHelperDown.SetAttribute ("OffTime", StringValue ("ns3::ConstantRandomVariable[Constant=0]"));
  onOffHelperDown.SetAttribute ("PacketSize", UintegerValue (flowsPacketsSize));
  onOffHelperDown.SetAttribute ("DataRate", StringValue (flowsDatarate));
  sourceApps.Add (onOffHelperDown.Install (n3));
  // Configure and install ping
  V4PingHelper ping = V4PingHelper (n3Interface.GetAddress (0));
```

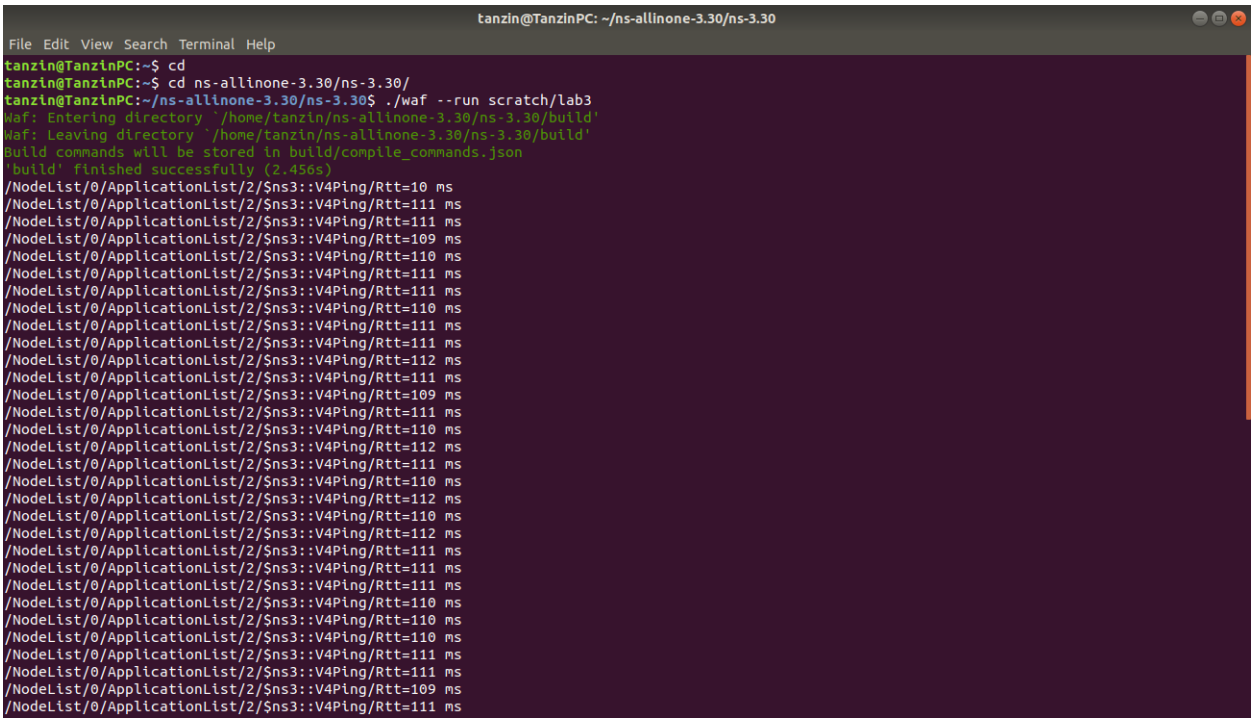
```
  ping.Install (n1);
  Config::Connect ("/NodeList/*/ApplicationList/*/$ns3::V4Ping/Rtt", MakeCallback (&PingRtt));
  uploadApp.Start (Seconds (0));
  uploadApp.Stop (Seconds (stopTime));
  downloadApp.Start (Seconds (0));
  downloadApp.Stop (Seconds (stopTime));
  sourceApps.Start (Seconds (0 + 0.1));
  sourceApps.Stop (Seconds (stopTime - 0.1));
  Ptr<OutputStreamWrapper> uploadGoodputStream = ascii.CreateFileStream (queueDiscType + "-upGoodput.txt");
  Simulator::Schedule (Seconds (samplingPeriod), &GoodputSampling, queueDiscType + "-upGoodput.txt", uploadApp,
                       uploadGoodputStream, samplingPeriod);
  Ptr<OutputStreamWrapper> downloadGoodputStream = ascii.CreateFileStream (queueDiscType + "-downGoodput.txt");
  Simulator::Schedule (Seconds (samplingPeriod), &GoodputSampling, queueDiscType + "-downGoodput.txt", downloadApp,
                       downloadGoodputStream, samplingPeriod);


  // Flow monitor
  Ptr<FlowMonitor> flowMonitor;
  FlowMonitorHelper flowHelper;
  flowMonitor = flowHelper.InstallAll();


  Simulator::Stop (Seconds (stopTime));
  Simulator::Run ();


  flowMonitor->SerializeToXmlFile(queueDiscType + "-flowMonitor.xml", true, true);
  Simulator::Destroy ();
  return 0
}
```

Output:


tanzin@TanzinPC: ~/ns-allinone-3.30/ns-3.30
File Edit View Search Terminal Help
tanzin@TanzinPC:~$ cd
tanzin@TanzinPC:~$ cd ns-allinone-3.30/ns-3.30/
tanzin@TanzinPC:~/ns-allinone-3.30/ns-3.30$ ./waf --run scratch/lab3
Waf: Entering directory `/home/tanzin/ns-allinone-3.30/ns-3.30/build'
Waf: Leaving directory `/home/tanzin/ns-allinone-3.30/ns-3.30/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (2.456s)
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=10 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=109 ms
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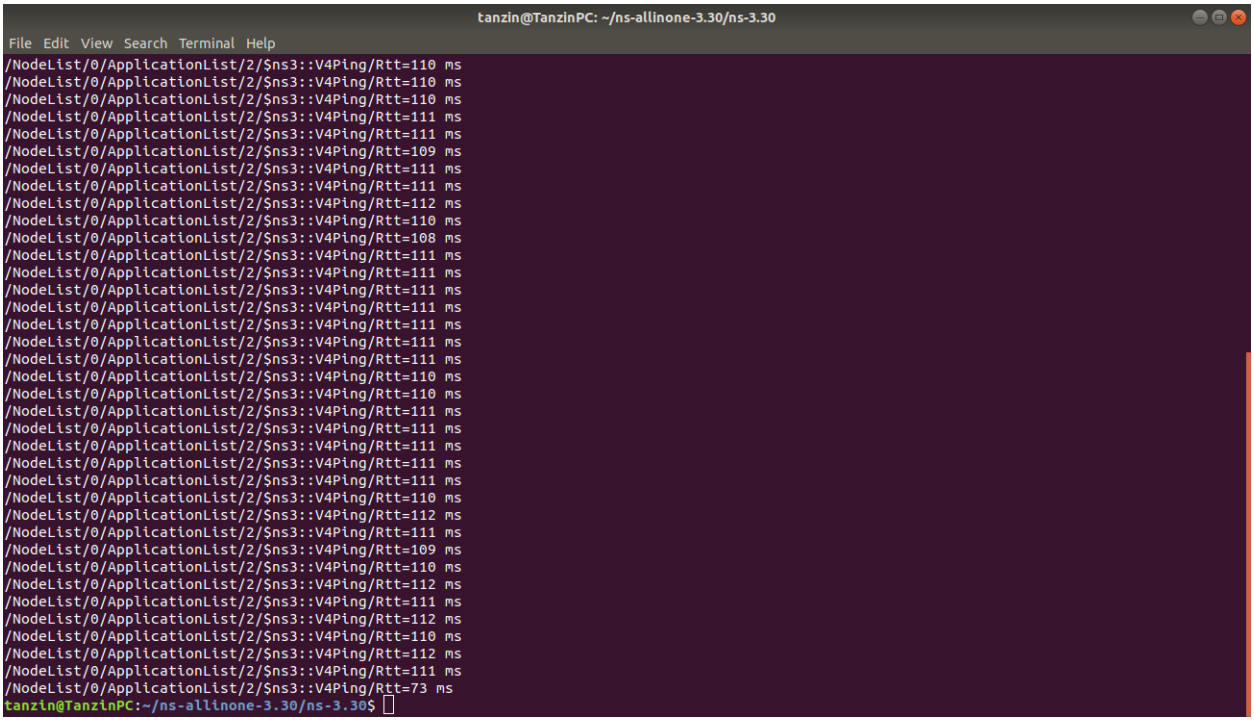
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms


tanzin@TanzinPC: ~/ns-allinone-3.30/ns-3.30
File Edit View Search Terminal Help
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
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/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=73 ms
tanzin@TanzinPC:~/ns-allinone-3.30/ns-3.30$

Conclusion:

Avoid routing loops, the manner in which they select preferred routes, using information is related to the specific characteristics of TCP and Router ques . Benefit of preventing issues with TCP and router queues loops is added by this.Connecting the network packages simultaneously is related to the TCP and Router.