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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

Submitted By	Submitted To
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Submission Date: 11-09-2020

Experiment No: 03

Name of Experiment: TCP and Router Queues.

Objectives:

1. For TCP and router queues, we have to create a simple topology with two client node1, node 2 on the left side and node3 and node4 in the right side.
2. We have to add drop tail queues of size QueueSize5 and QueueSize6 to Node5 and Node5 and Node6.
3. Install a TCP socket instance on Node1 that will connect to Node3.
4. We have to install a TCP socket instance on Node2 that will connect to Node3 and also Install a TCP socket instance on Node2 that will connect to Node4.
5. Measure packet loss and cwnd size, and plot graphs throughput/time, cwnd/time and packet loss/time for each of the flows.

Source Code:

```
// 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]
//   net devices queues with size of 100 packets  net devices queues with size of net devices
QueueSize packets [100]
// 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
//
// The files output will consist of a trace file with bytes in queue and of a trace file for limits
// (when BQL is enabled) both for bottleneck NetDevice on n2, two files with upload and
// download goodput for flows configuration and a file with flow monitor stats.
//

#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;
  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"));

  PointToPointHelper bottleneckLink;
  bottleneckLink.SetDeviceAttribute ("DataRate", StringValue (bandwidth));
  bottleneckLink.SetChannelAttribute ("Delay", StringValue (delay));
  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");
  }
 Config::SetDefault ("ns3::QueueBase::MaxSize", StringValue ("100p"));
 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);
```

```
  Config::SetDefault ("ns3::QueueBase::MaxSize", StringValue (std::to_string
(netdevicesQueueSize) + "p"));
  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:

```
File  Edit  View  Search  Terminal  Help
ahad17@ahad17s-hp-pavilion-notebook:~$ cd ns-allinone-3.29/ns-3.29
ahad17@ahad17s-hp-pavilion-notebook:~/ns-allinone-3.29/ns-3.29$ ./waf --run scratch/queue-discs-benchmark
Waf: Entering directory `/home/ahad17/ns-allinone-3.29/ns-3.29/build'
Waf: Leaving directory `/home/ahad17/ns-allinone-3.29/ns-3.29/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (5.258s)
/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
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
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/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=109 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
```

```
File  Edit  View  Search  Terminal  Help
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=109 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
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/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms
/NodeList/0/ApplicationList/2/$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/$ns3::V4Ping/Rtt=73 ms
ahad17@ahad17s-hp-pavilion-notebook:~/ns-allinone-3.29/ns-3.29$
```

Conclusion:

The specific characteristics of TCP and Router queues include the manner in which they avoid routing loops, the manner in which they select preferred routes, using information. This has the added benefit of preventing issues with TCP and router queues loops. TCP and router is related to connecting the network packages simultaneously.

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