Objective:

For TCP and router queues, we create a simple topology with two client node1, node 2 on the left side and node3 and node4 in the right side. We have to add drop tail queues of size QueueSize5 and QueueSize6 to Node5 and Node5 and Node6. Install a TCP socket instance on Node1 that will connect to Node3.

We 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. 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

#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
```

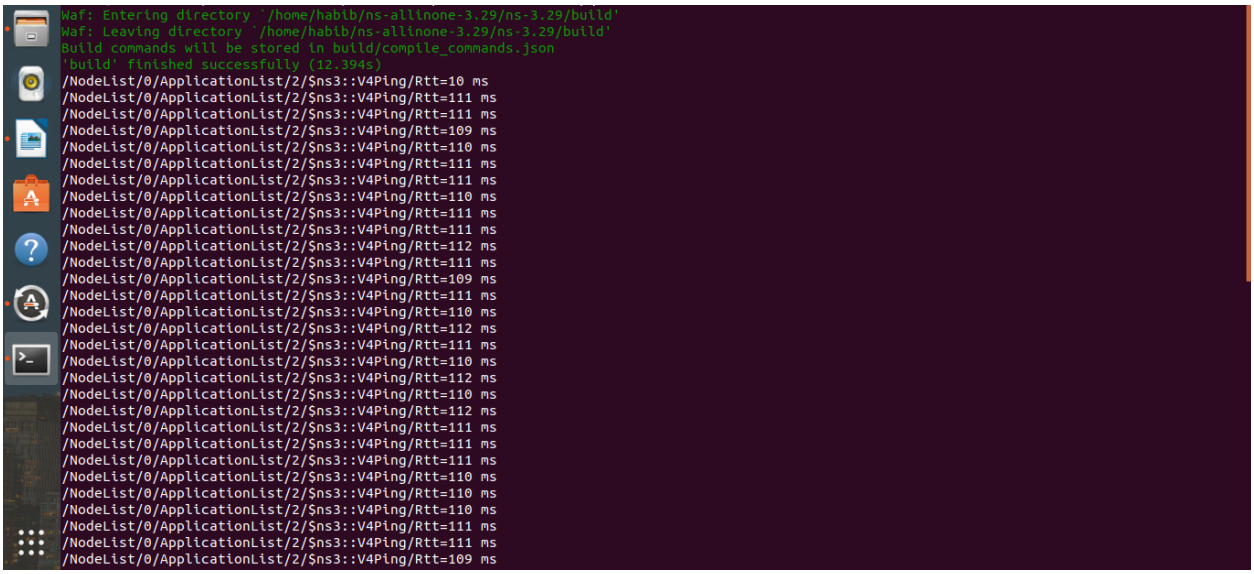
```
  // Bidirectional TCP streams with ping like flent tcp_bidirectional test.
  uint16_t port = 7;
  ApplicationContainer uploadApp, downloadApp, sourceApps;
  // Configure and install upload flow
  Address addUp (InetSocketAddress (Ipv4Address::GetAny (), port));
  PacketSinkHelper sinkHelperUp ("ns3::TcpSocketFactory",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

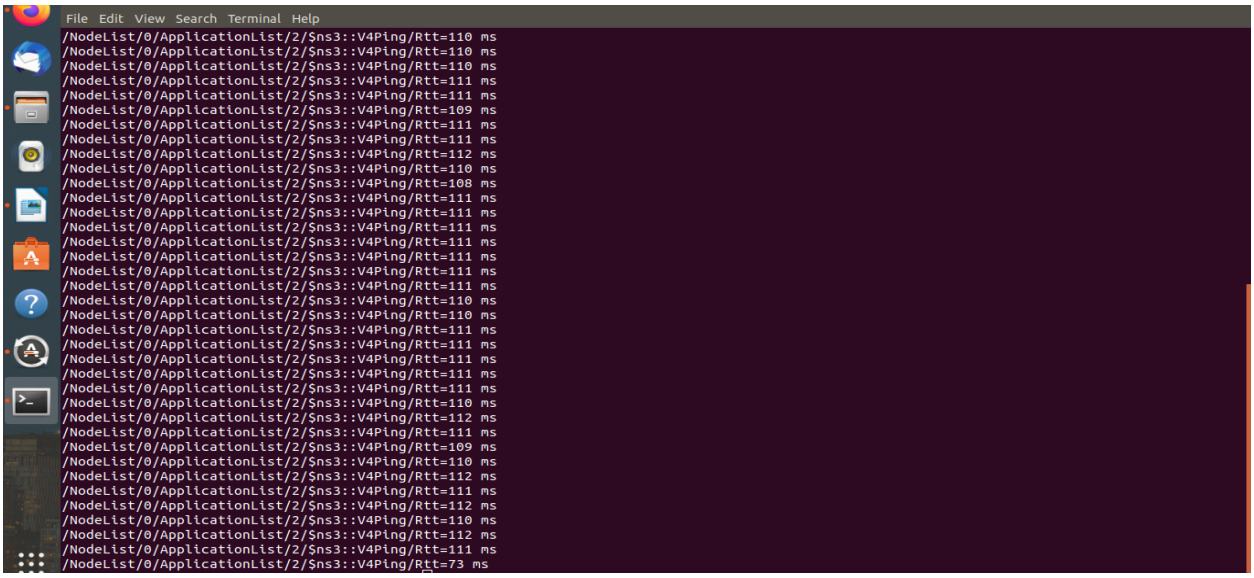
```
  // Configure and install download flow
  Address addDown (InetSocketAddress (Ipv4Address::GetAny (), port));
  PacketSinkHelper sinkHelperDown ("ns3::TcpSocketFactory", addDown);
  sinkHelperDown.SetAttribute ("Protocol", TypeIdValue
(TcpSocketFactory::GetTypeId ()));
  downloadApp.Add (sinkHelperDown.Install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





Conclusion:

We avoid routing loops by using TCP & Router Queues. TCP and router is related to connecting the network packages simultaneously. They select preferred routes. The issues with TCP and router loops are resolved.