MAWLANA BHASHANI SCIENCE AND TECHNOLOGY UNIVERSITY

LAB-REPORT

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Objective: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. 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 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. 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]

//   qdiscsPfifoFast with capacity              qdiscsqueueDiscType 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]

// 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 (intargc, 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;
CommandLinecmd;
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
PointToPointHelperaccessLink;
accessLink.SetDeviceAttribute ("DataRate", StringValue ("100Mbps"));
accessLink.SetChannelAttribute ("Delay", StringValue ("0.1ms"));
PointToPointHelperbottleneckLink;
bottleneckLink.SetDeviceAttribute ("DataRate", StringValue (bandwidth));
bottleneckLink.SetChannelAttribute ("Delay", StringValue (delay));
```

```
InternetStackHelper stack;

stack.InstallAll ();

  // Access link traffic control configuration

TrafficControlHelpertchPfifoFastAccess;

tchPfifoFastAccess.SetRootQueueDisc ("ns3::PfifoFastQueueDisc", "MaxSize", StringValue
("1000p"));

  // Bottleneck link traffic control configuration

TrafficControlHelpertchBottleneck;

  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::ClassIdListcid = 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"));
NetDeviceContainerdevicesAccessLink = 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"));
NetDeviceContainerdevicesBottleneckLink = bottleneckLink.Install (n2.Get (0), n3.Get (0));
QueueDiscContainerqdiscs;
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 ());
AsciiTraceHelperascii;
```

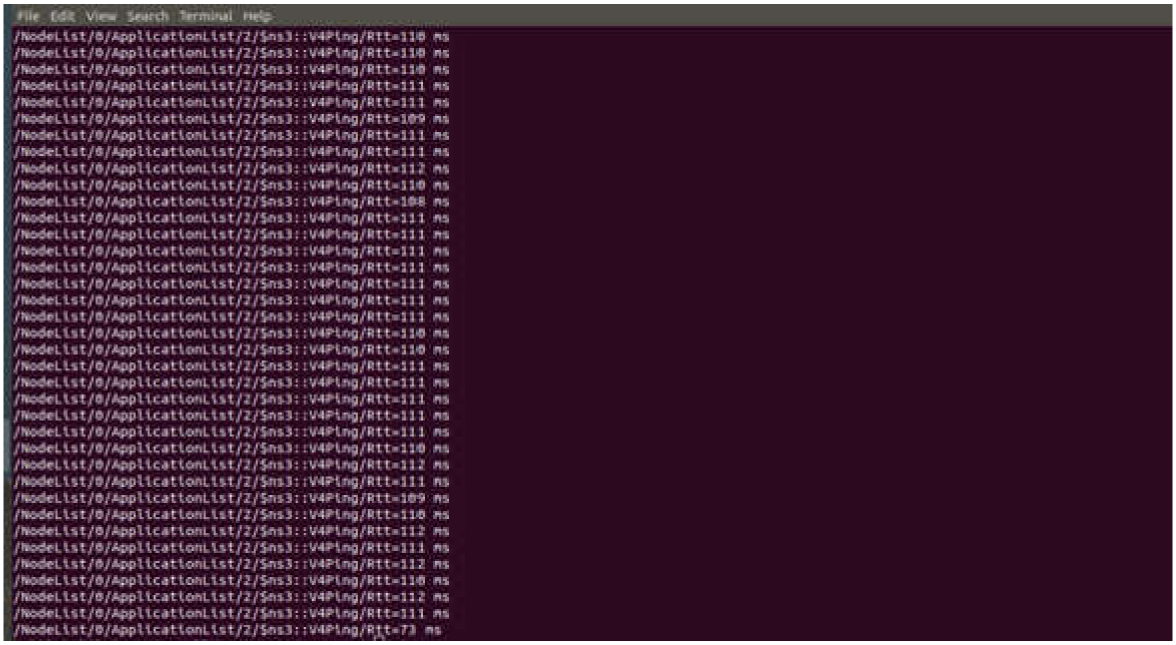
```
  if (bql)
    {
queueDiscType = queueDiscType + "-bql";
Ptr<OutputStreamWrapper>streamLimits = ascii.CreateFileStream (queueDiscType + "-
limits.txt");
queueLimits->TraceConnectWithoutContext ("Limit",MakeBoundCallback (&LimitsTrace,
streamLimits));
    }
Ptr<Queue<Packet>> queue = StaticCast<PointToPointNetDevice> (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 flenttcp_bidirectional test.
  uint16_t port = 7;
ApplicationContaineruploadApp, downloadApp, sourceApps;
  // Configure and install upload flow
  Address addUp (InetSocketAddress (Ipv4Address::GetAny (), port));
PacketSinkHelpersinkHelperUp ("ns3::TcpSocketFactory", addUp);
```

```
sinkHelperUp.SetAttribute ("Protocol", TypeIdValue (TcpSocketFactory::GetTypeId ()));

uploadApp.Add (sinkHelperUp.Install (n3));

InetSocketAddresssocketAddressUp = InetSocketAddress (n3Interface.GetAddress (0), port);

OnOffHelperonOffHelperUp ("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));

PacketSinkHelpersinkHelperDown ("ns3::TcpSocketFactory", addDown);

sinkHelperDown.SetAttribute ("Protocol", TypeIdValue (TcpSocketFactory::GetTypeId ()));

downloadApp.Add (sinkHelperDown.Install (n1));

InetSocketAddresssocketAddressDown = InetSocketAddress (n1Interface.GetAddress (0), port);

OnOffHelperonOffHelperDown ("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;
FlowMonitorHelperflowHelper;
flowMonitor = flowHelper.InstallAll();
Simulator::Stop (Seconds (stopTime));
```

```
Simulator::Run ();

flowMonitor->SerializeToXmlFile(queueDiscType + "-flowMonitor.xml", true, true);

Simulator::Destroy ();

  return 0;

}
```

Output:



```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 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
```

Conclusion: TCP flows and UDP flows share the same networks, the same routers, the same interfaces and possibly even the same queues. While TCP and queues work together to achieve these multiple goals, UDP sources ignore congestion conditions and keep sending packets regardless of congestion levels.