

LAB NO.:03

Name of Experiment: TCP and router queues

Objectives:

1. To create topology between nodes.
2. To install TCP sockets.
3. To measure router queues and packet loss.
4. To check their effect on congestion window size.

Source Code:

```
/* -*- Mode:C++; c-file-style:"gnu"; indent-  
tabs-mode:nil; -*- */
```

```
/*
```

```
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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
```

```
//
```

```
// 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.
```

```
//
```

```
// If you use an AQM as queue disc on the
bottleneck netdevices, you can observe that
the ping Rtt
```

```
// decrease. A further decrease can be
observed when you enable BQL.
```

```
#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"));

```

```
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::PopulateRouting
Tables ();
```

```
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::V4Pi
ng/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->  
SerializeToFile(queueDiscType + "-  
flowMonitor.xml", true, true);
```

```
    Simulator::Destroy ();
```

```
    return 0;
```

```
}
```

Output:



```
raisa@raisa-HP-Pavilion-Laptop-15-cc0xx:~/repos/ns-allinone-3.31/ns-3.31$ ./waf --run scratch/queue-discs-benchmark
```

```
Waf: Entering directory `/home/raisa/repos/ns-allinone-3.31/ns-3.31/build'
```

```
Waf: Leaving directory `/home/raisa/repos/ns-allinone-3.31/ns-3.31/build'
```

```
Build commands will be stored in build/compile_commands.json
```

```
'build' finished successfully (0.930s)
```

```
/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
```

```
/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
```

```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=109 ms
```

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

```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
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```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms
```

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

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

```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms
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```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms
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/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms
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/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
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/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
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```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms
```

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

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

```
/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=108 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=111 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=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
```

```
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms  
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms  
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=110 ms  
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=112 ms  
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=111 ms  
/NodeList/0/ApplicationList/2/$ns3::V4Ping/Rtt=73 ms  
raisa@raisa-HP-Pavilion-Laptop-15-cc0xx:~/repos/ns-allinone-3.31/ns-3.31$
```

Conclusion: Here in this experiment, router queues, packet drops and their effect on congestion window size are found successfully using NS-3 on linux platform.