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## **Experiment N0: 02**

### **Name of Experiments: TCP Variants**

#### **Objective:**

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:**

```
#include <fstream>
```

```
#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"
```

```
using namespace ns3;
```

```
NS_LOG_COMPONENT_DEFINE ("FifthScriptExample");
```

```
// =====
```

```
//
```

```
//      node 0          node 1
```

```
//  +-----+  +-----+
```

```
//  | ns-3 TCP |  | ns-3 TCP |
```

```
//  +-----+  +-----+
```

```
//  | 10.1.1.1 |  | 10.1.1.2 |
```

```
//  +-----+  +-----+
```

```
//  | point-to-point |  | point-to-point |
```

```
//  +-----+  +-----+
```

```
//      |          |
```

```
//      +-----+
```

```
//      5 Mbps, 2 ms
```

```
//  
  
//  
  
// We want to look at changes in the ns-3 TCP congestion window. We need  
  
// to crank up a flow and hook the CongestionWindow attribute on the socket  
  
// of the sender. Normally one would use an on-off application to generate a  
  
// flow, but this has a couple of problems. First, the socket of the on-off  
  
// application is not created until Application Start time, so we wouldn't be  
  
// able to hook the socket (now) at configuration time. Second, even if we  
  
// could arrange a call after start time, the socket is not public so we  
  
// couldn't get at it.  
  
//  
  
// So, we can cook up a simple version of the on-off application that does what  
  
// we want. On the plus side we don't need all of the complexity of the on-off  
  
// application. On the minus side, we don't have a helper, so we have to get  
  
// a little more involved in the details, but this is trivial.  
  
//  
  
// So first, we create a socket and do the trace connect on it; then we pass  
  
// this socket into the constructor of our simple application which we then  
  
// install in the source node.  
  
// =====
```

```
//
```

```
class MyApp : public Application
```

```
{
```

```
public:
```

```
    MyApp ();
```

```
    virtual ~MyApp();
```

```
    void Setup (Ptr<Socket> socket, Address address, uint32_t packetSize, uint32_t nPackets, DataRate dataRate);
```

```
private:
```

```
    virtual void StartApplication (void);
```

```
    virtual void StopApplication (void);
```

```
    void ScheduleTx (void);
```

```
    void SendPacket (void);
```

```
    Ptr<Socket>    m_socket;
```

```
    Address        m_peer;
```

```
    uint32_t       m_packetSize;
```

```
uint32_t    m_nPackets;  
  
DataRate    m_dataRate;  
  
EventId     m_sendEvent;  
  
bool        m_running;  
  
uint32_t    m_packetsSent;  
  
};
```

```
MyApp::MyApp ()
```

```
: m_socket (0),  
  
  m_peer (),  
  
  m_packetSize (0),  
  
  m_nPackets (0),  
  
  m_dataRate (0),  
  
  m_sendEvent (),  
  
  m_running (false),  
  
  m_packetsSent (0)
```

```
{  
  
}
```

```
MyApp::~MyApp()
```

```
{  
  
    m_socket = 0;  
  
}
```

void

MyApp::Setup (Ptr<Socket> socket, Address address, uint32\_t packetSize, uint32\_t nPackets, DataRate dataRate)

```
{  
  
    m_socket = socket;  
  
    m_peer = address;  
  
    m_packetSize = packetSize;  
  
    m_nPackets = nPackets;  
  
    m_dataRate = dataRate;  
  
}
```

void

MyApp::StartApplication (void)

```
{  
  
    m_running = true;  
  
    m_packetsSent = 0;  
  
    m_socket->Bind ();
```

```
m_socket->Connect (m_peer);  
  
SendPacket ();  
  
}
```

```
void
```

```
MyApp::StopApplication (void)
```

```
{  
  
    m_running = false;  
  
    if (m_sendEvent.IsRunning ())  
    {  
        Simulator::Cancel (m_sendEvent);  
    }  
  
}
```

```
if (m_socket)  
  
{  
  
    m_socket->Close ();  
  
}  
  
}
```

void

MyApp::SendPacket (void)

{

Ptr<Packet> packet = Create<Packet> (m\_packetSize);

m\_socket->Send (packet);

if (++m\_packetsSent < m\_nPackets)

{

ScheduleTx ();

}

}

void

MyApp::ScheduleTx (void)

{

if (m\_running)

{

Time tNext (Seconds (m\_packetSize \* 8 / static\_cast<double> (m\_dataRate.GetBitRate ())));

m\_sendEvent = Simulator::Schedule (tNext, &MyApp::SendPacket, this);

}



```
}
```

```
static void
```

```
CwndChange (uint32_t oldCwnd, uint32_t newCwnd)
```

```
{
```

```
    NS_LOG_UNCOND (Simulator::Now ().GetSeconds () << "\t" << newCwnd);
```

```
}
```

```
static void
```

```
RxDrop (Ptr<const Packet> p)
```

```
{
```

```
    NS_LOG_UNCOND ("RxDrop at " << Simulator::Now ().GetSeconds ());
```

```
}
```

```
int
```

```
main (int argc, char *argv[])
```

```
{
```

```
    CommandLine cmd;
```

```
    cmd.Parse (argc, argv);
```

```
NodeContainer nodes;
```

```
nodes.Create (2);
```

```
PointToPointHelper pointToPoint;
```

```
pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
```

```
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));
```

```
NetDeviceContainer devices;
```

```
devices = pointToPoint.Install (nodes);
```

```
Ptr<RateErrorModel> em = CreateObject<RateErrorModel> ();
```

```
em->SetAttribute ("ErrorRate", DoubleValue (0.00001));
```

```
devices.Get (1)->SetAttribute ("ReceiveErrorModel", PointerValue (em));
```

```
InternetStackHelper stack;
```

```
stack.Install (nodes);
```

```
Ipv4AddressHelper address;
```

```
address.SetBase ("10.1.1.0", "255.255.255.252");
```

```
Ipv4InterfaceContainer interfaces = address.Assign (devices);
```

```
uint16_t sinkPort = 8080;
```

```
Address sinkAddress (InetSocketAddress (interfaces.GetAddress (1), sinkPort));
```

```
PacketSinkHelper packetSinkHelper ("ns3::TcpSocketFactory", InetSocketAddress  
(Ipv4Address::GetAny (), sinkPort));
```

```
ApplicationContainer sinkApps = packetSinkHelper.Install (nodes.Get (1));
```

```
sinkApps.Start (Seconds (0.));
```

```
sinkApps.Stop (Seconds (20.));
```

```
Ptr<Socket> ns3TcpSocket = Socket::CreateSocket (nodes.Get (0), TcpSocketFactory::GetTypeId  
());
```

```
ns3TcpSocket->TraceConnectWithoutContext ("CongestionWindow", MakeCallback  
(&CwndChange));
```

```
Ptr<MyApp> app = CreateObject<MyApp> ();
```

```
app->Setup (ns3TcpSocket, sinkAddress, 1040, 1000, DataRate ("1Mbps"));
```

```
nodes.Get (0)->AddApplication (app);
```

```
app->SetStartTime (Seconds (1.));
```

```
app->SetStopTime (Seconds (20.));
```

```
devices.Get (1)->TraceConnectWithoutContext ("PhyRxDrop", MakeCallback (&RxDrop));
```

Simulator::Stop (Seconds (20));

Simulator::Run ();

Simulator::Destroy ();

return 0;

}

## Output:

```
bristy@bristy-HP-ProBook-450-G3 ~/Desktop/ns-allinone-3.28.1/ns-3.28.1
File Edit View Search Terminal Help
bristy@bristy-HP-ProBook-450-G3 ~$ cd Desktop
bristy@bristy-HP-ProBook-450-G3 ~/Desktop$ cd ns-allinone-3.28.1
bristy@bristy-HP-ProBook-450-G3 ~/Desktop/ns-allinone-3.28.1$ cd ns-3.28.1
bristy@bristy-HP-ProBook-450-G3 ~/Desktop/ns-allinone-3.28.1/ns-3.28.1$ ./waf --run scratch/fifth
Waf: Entering directory '/home/bristy/Desktop/ns-allinone-3.28.1/ns-3.28.1/build'
[ 961/2759] Compiling scratch/zermod.cc
[ 962/2759] Compiling scratch/third.cc
[ 963/2759] Compiling scratch/first.cc
[ 964/2759] Compiling scratch/scratch-simulator.cc
[1426/2759] Compiling scratch/fifth.cc
[1915/2759] Compiling scratch/hello-simulator.cc
[1930/2759] Compiling scratch/fourth.cc
[2092/2759] Compiling scratch/subdir/scratch-simulator-subdir.cc
[2093/2759] Compiling scratch/sixth.cc
[2365/2759] Compiling scratch/seventh.cc
[2652/2759] Linking build/scratch/scratch-simulator
[2653/2759] Linking build/scratch/third
[2700/2759] Linking build/scratch/second
[2701/2759] Linking build/scratch/subdir/subdir
[2743/2759] Linking build/scratch/first
[2744/2759] Linking build/scratch/fifth
[2745/2759] Linking build/scratch/fourth
[2746/2759] Linking build/scratch/hello-simulator
[2747/2759] Linking build/scratch/sixth
[2748/2759] Linking build/scratch/seventh
Waf: Leaving directory '/home/bristy/Desktop/ns-allinone-3.28.1/ns-3.28.1/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (22.907s)
1.08419 536
1.0893 1072
1.01328 1608
1.02167 2144
1.02999 2680
1.03831 3216
1.04663 3752
1.05495 4288
1.06327 4824
1.07159 5360
1.07991 5896
1.08823 6432
1.09655 6968
1.10487 7504
1.11319 8040
1.12151 8576
1.12983 9112
```

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```
1.02999 2680
1.03831 3216
1.04663 3752
1.05495 4288
1.06327 4824
1.07159 5360
1.07991 5896
1.08823 6432
1.09655 6968
1.10487 7504
1.11319 8040
1.12151 8576
1.12983 9112
RxDrop at 1.13696
1.13815 9648
1.1548 1072
1.16476 1340
1.17232 1554
1.18064 1738
1.18896 1903
1.19728 2053
1.2056 2192
1.21392 2323
1.22224 2446
1.23056 2563
1.23888 2675
1.2472 2782
1.25552 2885
1.26384 2984
1.27216 3080
1.28048 3173
1.2888 3263
1.29712 3351
1.30544 3436
1.31376 3519
1.32208 3600
1.3304 3679
1.33872 3757
1.34704 3833
1.35536 3907
1.36368 3980
1.372 4052
1.38032 4122
1.38864 4191
1.39696 4259
```

```
4.62512 11764
4.63344 11788
4.64176 11812
4.65008 11836
4.6584 11860
4.66672 11884
4.67504 11908
4.68336 11932
4.69168 11956
4.7 11980
4.70832 12003
4.71664 12026
4.72496 12049
4.73328 12072
4.7416 12095
4.74992 12118
4.75824 12141
4.76656 12164
4.77488 12187
4.7832 12210
4.79152 12233
4.79984 12256
4.80816 12279
4.81648 12302
4.8248 12325
4.83312 12348
4.84144 12371
4.84976 12394
4.85808 12417
4.8664 12440
4.87472 12463
4.88304 12486
4.89136 12509
4.89968 12531
4.908 12553
4.91632 12575
4.92464 12597
4.93296 12619
4.94128 12641
4.9496 12663
4.95792 12685
4.96624 12707
4.97456 12729
4.98288 12751
4.9912 12773
```

```
bristy@bristy-HP-ProBook-450-G3 ~/Desktop/ns-allinone-3.28.1/ns-3.28.1
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8.96816 7509
8.97648 7547
8.9848 7585
8.99312 7622
9.00144 7659
9.00976 7696
9.01808 7733
9.0264 7770
9.03472 7806
9.04304 7842
9.05136 7878
9.05968 7914
9.068 7950
9.07632 7986
9.08464 8021
9.09296 8056
9.10128 8091
9.1096 8126
9.11792 8161
9.12624 8196
9.13456 8231
9.14288 8265
9.1512 8299
9.15952 8333
9.16784 8367
9.17616 8401
9.18448 8435
9.1928 8469
9.20112 8502
9.20944 8535
9.21776 8568
9.22608 8601
9.2344 8634
9.24272 8667
9.25104 8700
9.25936 8733
9.26768 8765
9.276 8797
9.28432 8829
9.29264 8861
9.30096 8893
9.30928 8925
9.3176 8957
bristy@bristy-HP-ProBook-450-G3 ~/Desktop/ns-allinone-3.28.1/ns-3.28.1 $
```

**Conclusion:** From the lab, we have learnt how to create dumbbell topology, the process of installing TCP & UDP instance & got used to these. We have used the ns-3 tracing mechanism to record changes in congestion window size of the TCP instance over time & used gnuplot/matplotlib to visualize plots of cwnd vs time.