数据通信 NS3 作业-5&6

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一、 实验名称及内容

Lab5 & Lab6：

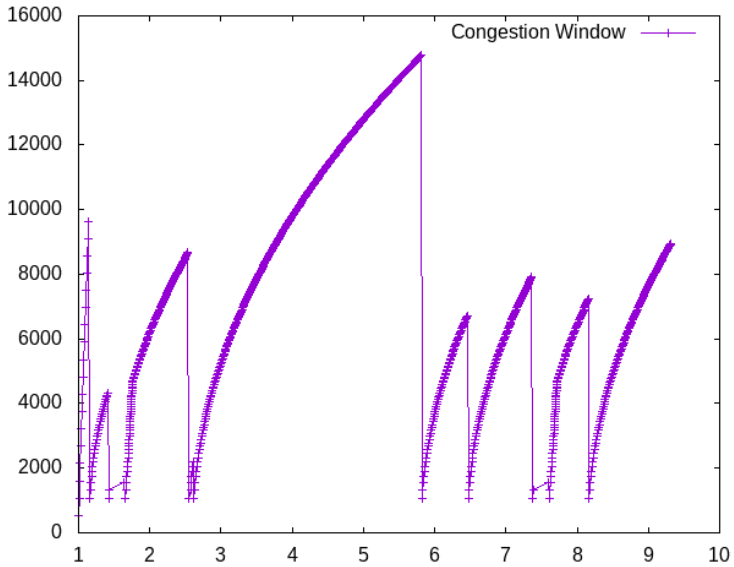
Background：

Fifth.cc 示例演示了一个极其重要的规则，在使用任何类型的跟踪源之前您必须了解该规则：即必须确保 Config::Connect 命令的目标存在，然后再尝试使用它，这与说一个对象在尝试调用它之前必须被实例化没有什么不同。

任何 ns-3 脚本中都存在三个基本执行阶段。

- The first phase is sometimes called "Configuration Time" or "Setup Time," and exists during the period when the `main` function of your script is running, but before `Simulator::Run` is called.
- The second phase is sometimes called "Simulation Time" and exists during the time period when `Simulator::Run` is actively executing its events.
- After it completes executing the simulation, `Simulator::Run` will return control back to the `main` function. When this happens, the script enters what can be called the "Teardown Phase," which is when the structures and objects created during setup are taken apart and released.

Demo:



二、 实验过程和结果

程序见压缩包内 lab5 和 lab6 的目录下。本次 ns3 的版本为 3.30。

```
#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"
#include "ns3/packet-sink.h"
```

头文件包含内容如上。

Lab 5:

Produce a figure showing TCP congestion window size, dropped packets and received packets, like in the following figure. Use the same network configuration as in mysixth.cc.

Sixth.cc is a script that writes the cwnd change and drop events developed in the example fifth.cc to disk in separate files. The cwnd changes are stored as a tab-separated ASCII file and the drop events are stored in a PCAP file.

The changes to make this happen are quite small. Actually this can be done in only 18 lines of code.

Hints:

1) **Modify mysixth.cc**
2) **Use trace source**

ns3::PointToPointNetDevice

PhyRxEnd: Trace source indicating a packet has been completely received by the device

Simulation：

$./waf --run scratch/lab5

Check the .cwnd file, and use gnuplot to draw a figure.

$ gnuplot:

set terminal png size 960, 720

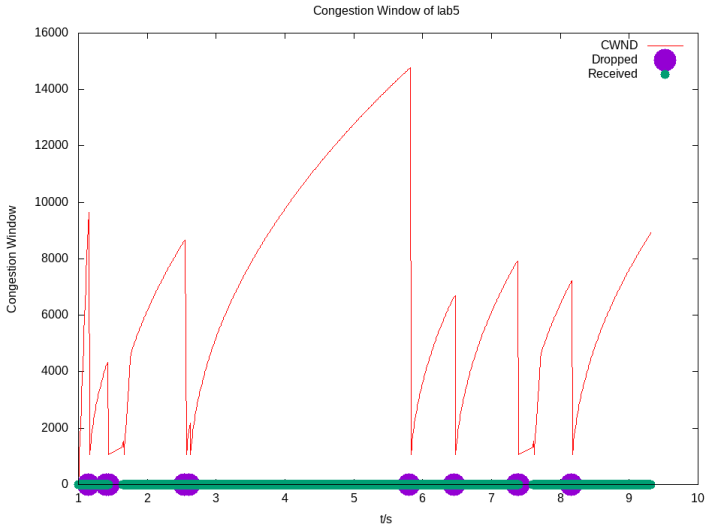
set output "lab5.png"

set xlabel "t/s"

set ylabel "Congestion Window"

set title "Congestion Window of lab5"

plot "lab5.cwnd" using 1:2 title "CWND" with lines lc rgb "red" , "lab5_drop.cwnd" using 1:2 title "Dropped" with points lt 1 pt 7 ps 5, "lab5_recv.cwnd" using 1:2 title "Received" with points lt 2 pt 7 ps 2



Lab 6:

有两种方法可以将跟踪接收器连接到 CongestionWindow。

- **Method 1: using SocketObject->TraceConnect(……)**

```
./src/test/ns3tcp/ns3tcp-cwnd-test-suite.cc:  ns3TcpSocket->TraceConnectWithout
Context ("CongestionWindowInflated", MakeCallback (&Ns3TcpCwndTestCase2::CwndCh
ange, this));
./src/test/ns3tcp/ns3tcp-cwnd-test-suite.cc:  ns3TcpSocket->TraceConnectWithout
Context ("CongestionWindow", MakeCallback (&Ns3TcpCwndTestCase2::CwndChangeNotI
nflated, this));
```

- **Method 2: using Config::Connect(……)**

```
./examples/tcp/tcp-large-transfer.cc:  Config::ConnectWithoutContext ("/NodeLis
t/0/$ns3::TcpL4Protocol/SocketList/0/CongestionWindow", MakeCallback (&CwndTrac
er));
./examples/tcp/tcp-variants-comparison.cc:  Config::ConnectWithoutContext ("/No
deList/1/$ns3::TcpL4Protocol/SocketList/0/CongestionWindow", MakeCallback (&Cwn
dTracer));
```

我们在 lab5 中使用了方法 1，在 lab6.cc 中使用了方法 2 来得到 TCP 拥塞窗口的值。

Hint:

1) Use a two-node point-to-pint topology. Use BulkSendApplication on 1 node, and PacketSink on the other node. (refer to examples/tcp/tcp-bulk-send.cc)
2) Use the link error model as in mysixth.cc
3) To use Config::Connect (……) , you need to create a simulator event that is run after the dynamic object is created and hook the trace when that event is executed. Refer to /examples/tcp/tcp-variants-comparison.cc for more details.

Config：connectWithoutContext 方法：

```
static void

TraceCwndChange(std::string traceName)

{

  Ptr<OutputStreamWrapper> stream = asciiTraceHelper.CreateFileStream (traceName.c_str());
```

```
  Config::ConnectWithoutContext (
    "/NodeList/0/$ns3::TcpL4Protocol/SocketList/0/CongestionWindow",
    MakeBoundCallback (&CwndChange, stream));
}
```

```
static void
TraceDrop(std::string dropName)
{
  Ptr<OutputStreamWrapper> DropFile = asciiTraceHelper.CreateFileStream (dropName.c_str());
  Config::ConnectWithoutContext (
    "/NodeList/1/DeviceList/0/$ns3::PointToPointNetDevice/PhyRxDrop",
    MakeBoundCallback (&RxDrop, DropFile));
}
```

```
static void
TraceRecv(std::string recvName)
{
  Ptr<OutputStreamWrapper> RecvFile = asciiTraceHelper.CreateFileStream (recvName);
  Config::ConnectWithoutContext (
    "/NodeList/1/DeviceList/0/$ns3::PointToPointNetDevice/PhyRxEnd",
    MakeBoundCallback (&RxEnd, RecvFile));
}
```

Simulation：

$./waf --run scratch/lab6

Check the .cwnd file, and use gnuplot to draw a figure.

$ gnuplot

set terminal png size 960, 720

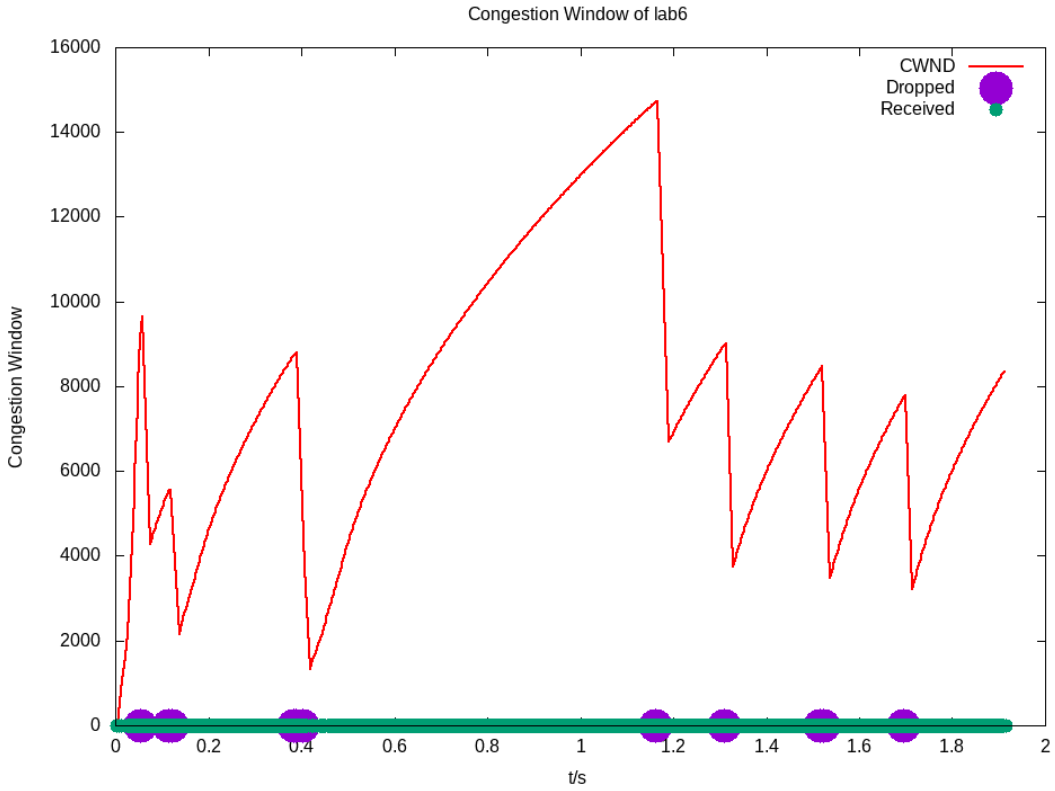
set output "lab6.png"

set xlabel "t/s"

set ylabel "Congestion Window"

set title "Congestion Window of lab6"

plot "lab6.cwnd" using 1:2 title "CWND" with lines lc rgb "red" , "lab6_drop.cwnd" using 1:2 title "Dropped" with points lt 1 pt 7 ps 5, "lab6_recv.cwnd" using 1:2 title "Received" with points lt 2 pt 7 ps 2



三、 实验思考:

关于 cwnd 的计算机网络控制算法:

拥塞窗口（cwnd):

技术解释: TCP 流量控制方法之一，如果说通告窗口是通过接收数据的一端进行的流量控制，那么拥塞窗口就是发送端进行的流量控制，发送端发送数据包的字节数不会超过拥塞窗口的大小。

1) 慢启动算法

设计背景:

当发送方和接收方在一个速率较慢的链路时，如果一开始发送的数据太多，可能导致耗尽路由器的缓存空间，从而引发网络崩溃，所以 tcp 在进行数据发送时，选择逐步增加分组的数量来避免此类问题。

具体算法:

1. 当 TCP 握手完成后，拥塞窗口会被初始化为一个报文段大小，也就是每次只能发送一个报文段
2. 每收到一个 ACK，拥塞窗口的大小就会增加 1 个报文段，以此类推
3. 最终数据发送的字节数，将根据通告窗口和拥塞窗口的较小值作为上限
4. 当到某一个阈值后，可能在网络上出现丢包，此时将会进入拥塞避免算法

2) 拥塞避免算法

设计背景:

1. 认定当分组丢失的时候，网络上就一定发生了拥塞
2. 不考虑移动信号不稳定的情况
3. 分组损坏的可能性较低

具体算法：

1. 当进行拥塞避免时，cwnd 每次收到 ack 后不在进行指数倍增加，具体增加的方法为 cwnd = cwnd + 1/cwnd
2. 当拥塞发生时，发送数据包丢失，例如超时确认或者重复的确认包，ssthress 将会被设置为当前窗口（拥塞窗口和通告窗口的最小值）的一半
3. 如果是因为超时确认引起的丢包，那么 cwnd 将会被初始化为 1 个报文段

关于使用 Bulk 类：

此流量生成器只是尽可能快地将数据发送到 MaxBytes，或者直到应用程序停止（如果 MaxBytes 为零）。一旦下层发送缓冲区被填满，它就会等到空间有空来发送更多数据，基本上保持恒定的数据流。仅支持 SOCK_STREAM 和 SOCK_SEQPACKET 套接字。例如，可以使用 TCP 套接字，但不能使用 UDP 套接字。

可以在属性中设置发送大小，最大字节数等参数以控制传输速率。