Explanation of the Mininet script :

```
from mininet.net import Mininet
from mininet.node import Controller, CPULimitedHost, Node
from mininet.cli import CLI
from mininet.log import setLogLevel, info
from mininet.topo import Topo
from mininet.link import TCLink
from mininet.util import dumpNodeConnections, custom, pmonitor
from datetime import datetime
from time import time
from signal import SIGINT
from subprocess import Popen

CAPTURE = True

def enable_tcp_sack():
    Popen("sysctl -w net.ipv4.tcp_sack=1", shell=True).wait()
    Popen("sysctl -w net.ipv4.tcp_dsack=1", shell=True).wait()

def disable_tcp_sack():
    Popen("sysctl -w net.ipv4.tcp_sack=0", shell=True).wait()
    Popen("sysctl -w net.ipv4.tcp_dsack=0", shell=True).wait()

def iperf_and_tcpdump_test( src, sink, capture=False ):
    now = datetime.now()
    timestamp = now.strftime("%Y%m%d%H%M%S")
    # start iperf server and clients
    popens = {}
    popens[ sink ] = sink.popen( "iperf -w 131072 -s" )
    if ( capture ):
        popens[ 'tcpdump' ] = sink.popen( "tcpdump -w capture_sack_"+timestamp+".pcap" )
    popens[ src ] = src.popen( "iperf -w 131072 -c %s" % sink.IP() )
    # monitor them and print output
    seconds = 20
    print "monitoring output for", seconds, "seconds"
    endTime = time() + seconds
    for host, line in pmonitor( popens, timeoutms=500 ):
        if host and not host == 'tcpdump':
            if line.strip():
                print "<%s>: %s" % ( host.name, line.strip() )
        if time() >= endTime:
            for p in popens.values():
                p.send_signal( SIGINT )
    # kill iperf sessions
    for host in src, sink:
        host.cmd('kill %iperf')
    if ( capture ):
        sink.cmd('kill %tcpdump')

def perfNet():

    # Create a node in root namespace
    root = Node( 'root', inNamespace=False )

    net = Mininet( controller=Controller, link=TCLink )

    info( '*** Adding controller\n' )
    net.addController( 'c0' )

    info( '*** Adding hosts\n' )
    h1 = net.addHost( 'h1', ip='10.0.0.1' )
    h2 = net.addHost( 'h2', ip='10.0.0.2' )

    info( '*** Adding switch\n' )
    s3 = net.addSwitch( 's3' )

    info( '*** Creating links\n' )
    net.addLink( h1, s3 )
    # 1 Mbps, 40ms delay, 10% loss
    net.addLink( h2, s3, bw=1, delay='40ms', loss=10, use_htb=True, max_queue_size = 1000 )

    info( '\n*** Starting network\n')
    net.start()

    # info( '*** Testing network connectivity\n')
    # net.pingAll()

    h1, h2 = net.getNodeByName('h1', 'h2')

    info( '*** Testing with TCP SACK disabled\n' )
    disable_tcp_sack()
    iperf_and_tcpdump_test( h1, h2, CAPTURE )

    info( '*** Testing with TCP SACK enabled\n' )
    enable_tcp_sack()
    iperf_and_tcpdump_test( h1, h2, CAPTURE )

    # info( '*** Running CLI\n' )
    # CLI( net )

    info( '*** Stopping network' )
    net.stop()
```

```
if __name__ == '__main__':
    setLogLevel( 'info' )
    perfNet()
```

Analysis

The script which was provided in the website creates two systems along with a switch. The script then tests the performance of a TCP connection with and without the sack. The pcap files which were generated after running the script are used to compare the performance of the two cases i.e. with and without the stack using tcptrace. The results/plots were shown below.

Results:

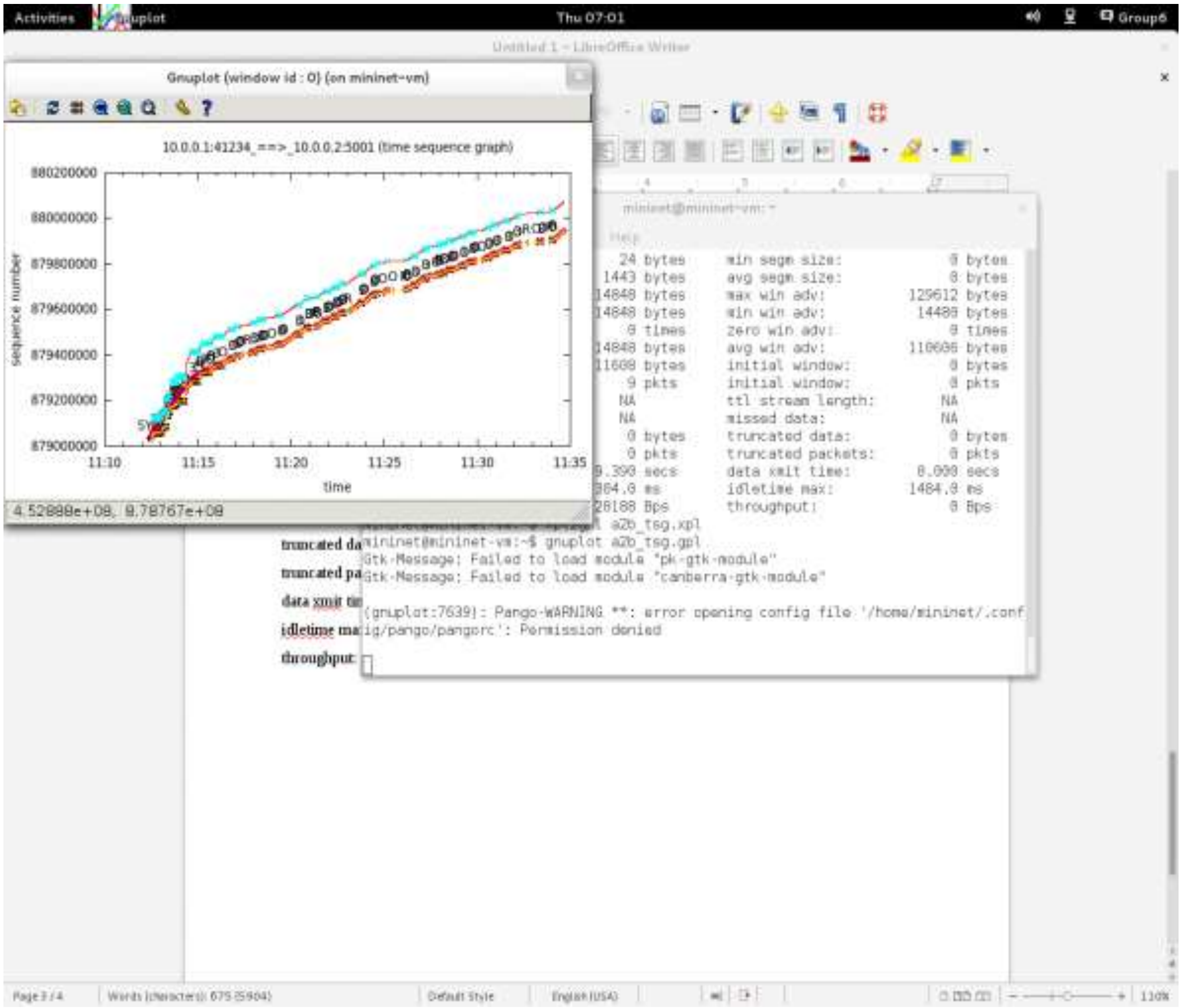
```
mininet@mininet-vm:~$ sudo ./sack_test.py
*** Adding controller
*** Adding hosts
*** Adding switch
*** Creating links
(1.00Mbit 40ms delay 10% loss) (1.00Mbit 40ms delay 10% loss)
*** Starting network
*** Configuring hosts
h1 h2
*** Starting controller
*** Starting 1 switches
s3 (1.00Mbit 40ms delay 10% loss)
*** Testing with TCP SACK disabled
net.ipv4.tcp_sack = 0
net.ipv4.tcp_dsack = 0
monitoring output for 20 seconds
<h2>: ------------------------------------------------------------
<h2>: Server listening on TCP port 5001
<h2>: TCP window size:  256 KByte (WARNING: requested  128 KByte)
<h2>: ------------------------------------------------------------
<h1>: ------------------------------------------------------------
<h1>: Client connecting to 10.0.0.2, TCP port 5001
<h1>: TCP window size:  256 KByte (WARNING: requested  128 KByte)
```

```
<h1>: ------------------------------------------------------------
<h1>: [  4] local 10.0.0.1 port 41225 connected with 10.0.0.2 port 5001
<h2>: [  5] local 10.0.0.2 port 5001 connected with 10.0.0.1 port 41225
<h1>: [ ID] Interval       Transfer     Bandwidth
<h1>: [  4]  0.0-18.1 sec   512 KBytes   231 Kbits/sec
*** Testing with TCP SACK enabled
net.ipv4.tcp_sack = 1
net.ipv4.tcp_dsack = 1
monitoring output for 20 seconds
<h2>: ------------------------------------------------------------
<h2>: Server listening on TCP port 5001
<h2>: TCP window size:  256 KByte (WARNING: requested  128 KByte)
<h2>: ------------------------------------------------------------
<h1>: ------------------------------------------------------------
<h1>: Client connecting to 10.0.0.2, TCP port 5001
<h1>: TCP window size:  256 KByte (WARNING: requested  128 KByte)
<h1>: ------------------------------------------------------------
<h1>: [  4] local 10.0.0.1 port 41226 connected with 10.0.0.2 port 5001
<h2>: [  5] local 10.0.0.2 port 5001 connected with 10.0.0.1 port 41226
<h1>: [ ID] Interval       Transfer     Bandwidth
<h1>: [  4]  0.0-14.1 sec   768 KBytes   445 Kbits/sec
<h2>: [ ID] Interval       Transfer     Bandwidth
<h2>: [  5]  0.0-18.9 sec   768 KBytes   333 Kbits/sec
*** Stopping network*** Stopping 1 switches
s3 ..
*** Stopping 2 hosts
h1 h2
*** Stopping 1 controllers
c0
*** Done
mininet@mininet-vm:~$
```

```
mininet@mininet-vm:~$ tcptrace -l capture_sack_20140508104258.pcap
1 arg remaining, starting with 'capture_sack_20140508104258.pcap'
Ostermann's tcptrace -- version 6.6.7 -- Thu Nov  4, 2004

548 packets seen, 538 TCP packets traced
elapsed wallclock time: 0:00:00.114549, 4783 pkts/sec analyzed
trace file elapsed time: 0:00:19.606865
TCP connection info:
1 TCP connection traced:
TCP connection 1:
        host a:        10.0.0.1:41230
        host b:        10.0.0.2:5001
        complete conn: no       (SYNs: 2)  (FINs: 0)
        first packet:  Thu May  8 10:42:58.611674 2014
        last packet:   Thu May  8 10:43:18.122613 2014
        elapsed time:  0:00:19.510939
        total packets: 538
        filename:      capture_sack_20140508104258.pcap
  a->b:                            b->a:
    total packets:          288           total packets:          250
    ack pkts sent:          287           ack pkts sent:          250
    pure acks sent:           1           pure acks sent:         249
    sack pkts sent:           0           sack pkts sent:           0
    dsack pkts sent:          0           dsack pkts sent:          0
```

```
max sack blks/ack:         0         max sack blks/ack:         0
unique bytes sent:    393880         unique bytes sent:         0
actual data pkts:        286         actual data pkts:          0
actual data bytes:    412704         actual data bytes:         0
rexmt data pkts:          13         rexmt data pkts:           0
rexmt data bytes:      18824         rexmt data bytes:          0
zwnd probe pkts:           0         zwnd probe pkts:           0
zwnd probe bytes:          0         zwnd probe bytes:          0
outoforder pkts:          37         outoforder pkts:           0
pushed data pkts:         27         pushed data pkts:          0
SYN/FIN pkts sent:       1/0         SYN/FIN pkts sent:       1/0
req 1323 ws/ts:          Y/Y         req 1323 ws/ts:          Y/Y
adv wind scale:            9         adv wind scale:            2
urgent data pkts:     0 pkts         urgent data pkts:     0 pkts
urgent data bytes:   0 bytes         urgent data bytes:   0 bytes
mss requested:    1460 bytes         mss requested:    1460 bytes
max segm size:    1448 bytes         max segm size:       0 bytes
min segm size:      24 bytes         min segm size:       0 bytes
avg segm size:    1443 bytes         avg segm size:       0 bytes
max win adv:     14848 bytes         max win adv:    129612 bytes
min win adv:     14848 bytes         min win adv:     14480 bytes
zero win adv:        0 times         zero win adv:        0 times
avg win adv:     14848 bytes         avg win adv:    110606 bytes
initial window:  11608 bytes         initial window:      0 bytes
initial window:       9 pkts         initial window:       0 pkts
ttl stream length:        NA         ttl stream length:        NA
missed data:              NA         missed data:              NA
truncated data:      0 bytes         truncated data:      0 bytes
truncated packets:    0 pkts         truncated packets:    0 pkts
data xmit time:  19.390 secs         data xmit time:   0.000 secs
idletime max:      1304.0 ms         idletime max:      1484.0 ms
throughput:        20188 Bps         throughput:            0 Bps
```



```
      24 bytes      min segm size:             0 bytes
    1443 bytes      avg segm size:             0 bytes
   14848 bytes      max win adv:          129612 bytes
   14848 bytes      min win adv:           14480 bytes
       0 times      zero win adv:              0 times
   14848 bytes      avg win adv:          110606 bytes
   11608 bytes      initial window:            0 bytes
       9 pkts       initial window:            0 pkts
      NA            ttl stream length:        NA
      NA            missed data:              NA
       0 bytes      truncated data:            0 bytes
       0 pkts       truncated packets:         0 pkts
   9.390 secs       data xmit time:        0.000 secs
   364.0 ms         idletime max:         1484.0 ms
   28188 Bps        throughput:                0 Bps
                   l a2b_tsg.xpl
mininet@mininet-vm:~$ gnuplot a2b_tsg.gpl
Gtk-Message: Failed to load module "pk-gtk-module"
Gtk-Message: Failed to load module "canberra-gtk-module"

(gnuplot:7639): Pango-WARNING **: error opening config file '/home/mininet/.conf
ig/pango/pangorc': Permission denied
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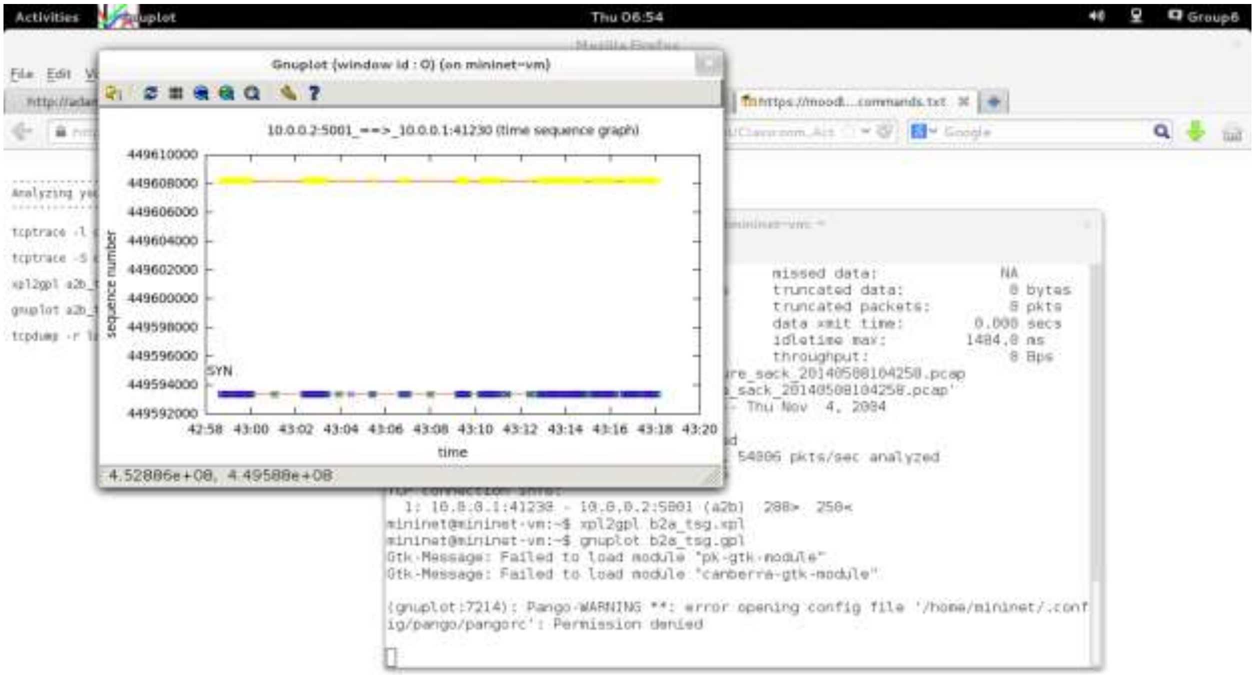


```
           missed data:              NA
           truncated data:            0 bytes
           truncated packets:         0 pkts
           data xmit time:        0.000 secs
           idletime max:         1484.0 ms
           throughput:                0 Bps
re_sack_20140508104258.pcap
_sack_20140508104258.pcap'
- Thu Nov  4, 2004

d
 54806 pkts/sec analyzed

  1: 10.0.0.1:41230 - 10.0.0.2:5001 (a2b)  288>  250<
mininet@mininet-vm:~$ xpl2gpl b2a_tsg.xpl
mininet@mininet-vm:~$ gnuplot b2a_tsg.gpl
Gtk-Message: Failed to load module "pk-gtk-module"
Gtk-Message: Failed to load module "canberra-gtk-module"

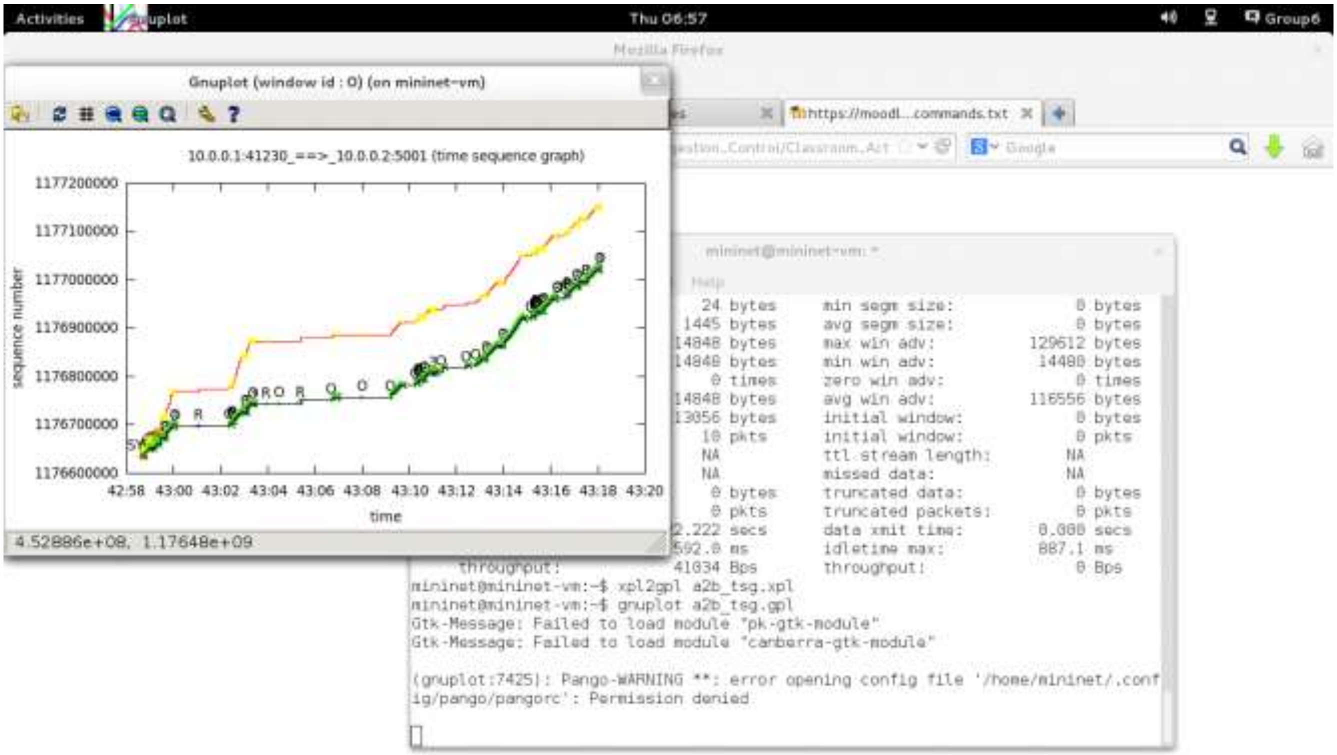
(gnuplot:7214): Pango-WARNING **: error opening config file '/home/mininet/.conf
ig/pango/pangorc': Permission denied
```

```
mininet@mininet-vm:~$ tcptrace -l capture_sack_20140508111112.pcap
1 arg remaining, starting with 'capture_sack_20140508111112.pcap'
Ostermann's tcptrace -- version 6.6.7 -- Thu Nov  4, 2004

PCAP error: 'truncated dump file; tried to read 1514 captured bytes, only got 518'
1235 packets seen, 1225 TCP packets traced
elapsed wallclock time: 0:00:00.005826, 211980 pkts/sec analyzed
trace file elapsed time: 0:00:22.302483
TCP connection info:
1 TCP connection traced:
TCP connection 1:
	host a:        10.0.0.1:41234
	host b:        10.0.0.2:5001
	complete conn: no       (SYNs: 2)  (FINs: 0)
```

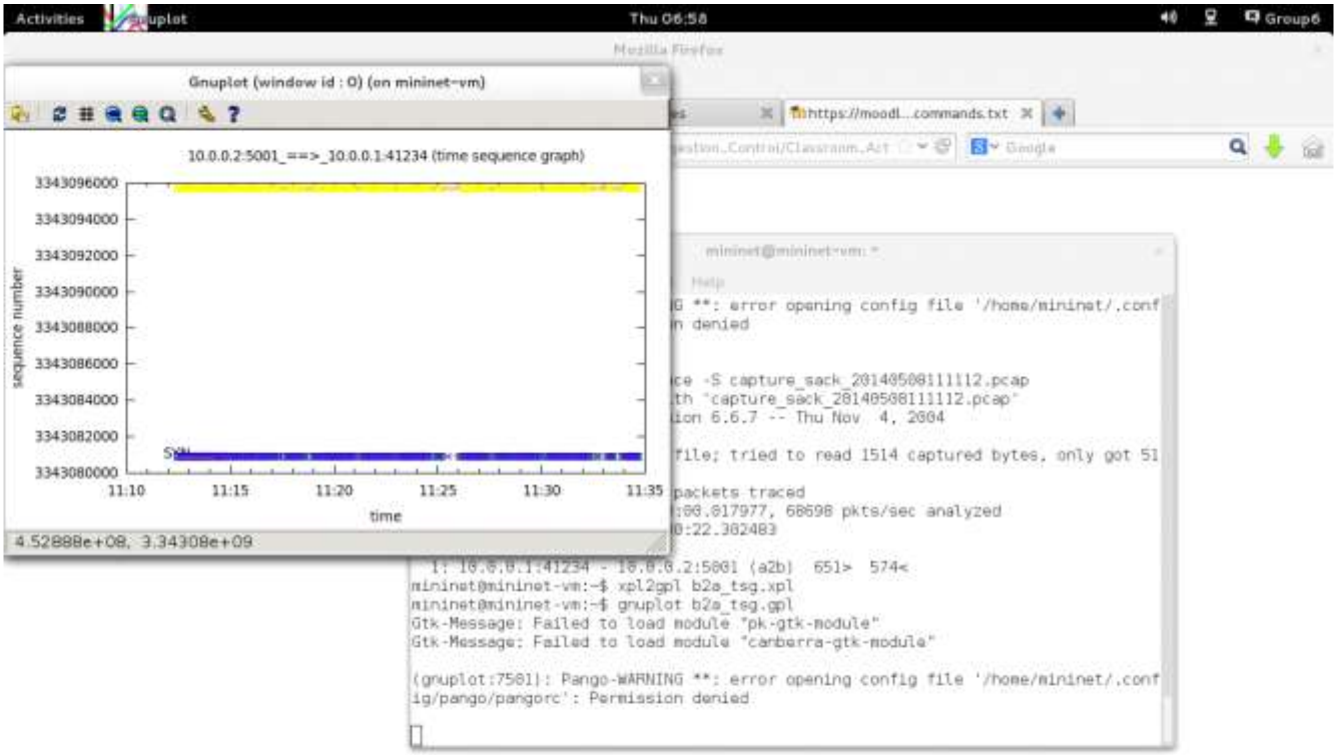
```
        first packet:  Thu May  8 11:11:12.387149 2014
        last packet:   Thu May  8 11:11:34.689632 2014
        elapsed time:  0:00:22.302483
        total packets: 1225
        filename:      capture_sack_20140508111112.pcap
   a->b:                              b->a:
     total packets:            651           total packets:            574
     ack pkts sent:            650           ack pkts sent:            574
     pure acks sent:             1           pure acks sent:           573
     sack pkts sent:             0           sack pkts sent:             0
     dsack pkts sent:            0           dsack pkts sent:            0
     max sack blks/ack:          0           max sack blks/ack:          0
     unique bytes sent:     915160           unique bytes sent:          0
     actual data pkts:         649           actual data pkts:           0
     actual data bytes:     938328           actual data bytes:          0
     rexmt data pkts:           16           rexmt data pkts:            0
     rexmt data bytes:       23168           rexmt data bytes:           0
     zwnd probe pkts:            0           zwnd probe pkts:            0
     zwnd probe bytes:           0           zwnd probe bytes:           0
     outoforder pkts:           59           outoforder pkts:            0
     pushed data pkts:          36           pushed data pkts:           0
     SYN/FIN pkts sent:        1/0           SYN/FIN pkts sent:        1/0
     req 1323 ws/ts:           Y/Y           req 1323 ws/ts:           Y/Y
     adv wind scale:             9           adv wind scale:             2
     urgent data pkts:           0 pkts      urgent data pkts:           0 pkts
     urgent data bytes:          0 bytes     urgent data bytes:          0 bytes
     mss requested:           1460 bytes     mss requested:           1460 bytes
     max segm size:           1448 bytes     max segm size:              0 bytes
     min segm size:             24 bytes     min segm size:              0 bytes
     avg segm size:           1445 bytes     avg segm size:              0 bytes
     max win adv:            14848 bytes     max win adv:           129612 bytes
     min win adv:            14848 bytes     min win adv:            14480 bytes
     zero win adv:               0 times     zero win adv:               0 times
```

avg win adv:	14848 bytes	avg win adv:	116556 bytes
initial window:	13056 bytes	initial window:	0 bytes
initial window:	10 pkts	initial window:	0 pkts
ttl stream length:	NA	ttl stream length:	NA
missed data:	NA	missed data:	NA
truncated data:	0 bytes	truncated data:	0 bytes
truncated packets:	0 pkts	truncated packets:	0 pkts
data xmit time:	22.222 secs	data xmit time:	0.000 secs
idletime max:	592.0 ms	idletime max:	887.1 ms
throughput:	**41034 Bps**	throughput:	0 Bps



```
   24 bytes      min segm size:              0 bytes
 1445 bytes      avg segm size:              0 bytes
14848 bytes      max win adv:           129612 bytes
14848 bytes      min win adv:            14480 bytes
    0 times      zero win adv:               0 times
14848 bytes      avg win adv:           116556 bytes
13056 bytes      initial window:             0 bytes
   10 pkts       initial window:             0 pkts
   NA            ttl stream length:        NA
   NA            missed data:              NA
    0 bytes      truncated data:             0 bytes
    0 pkts       truncated packets:          0 pkts
2.222 secs       data xmit time:         0.000 secs
592.0 ms         idletime max:           887.1 ms
     throughput:              41034 Bps      throughput:                 0 Bps
mininet@mininet-vm:~$ xpl2gpl a2b_tsg.xpl
mininet@mininet-vm:~$ gnuplot a2b_tsg.gpl
Gtk-Message: Failed to load module "pk-gtk-module"
Gtk-Message: Failed to load module "canberra-gtk-module"

(gnuplot:7425): Pango-WARNING **: error opening config file '/home/mininet/.conf
ig/pango/pangorc': Permission denied
```



```
G **: error opening config file '/home/mininet/.conf
n denied


ce -S capture_sack_20140508111112.pcap
th 'capture_sack_20140508111112.pcap'
ion 6.6.7 -- Thu Nov  4, 2004

file; tried to read 1514 captured bytes, only got 51

packets traced
:00.017977, 68698 pkts/sec analyzed
0:22.302483

  1: 10.0.0.1:41234 - 10.0.0.2:5001 (a2b)   651>  574<
mininet@mininet-vm:~$ xpl2gpl b2a_tsg.xpl
mininet@mininet-vm:~$ gnuplot b2a_tsg.gpl
Gtk-Message: Failed to load module "pk-gtk-module"
Gtk-Message: Failed to load module "canberra-gtk-module"

(gnuplot:7501): Pango-WARNING **: error opening config file '/home/mininet/.conf
ig/pango/pangorc': Permission denied

```