



دانشکده مهندسی کامپیوتر  
آزمایشگاه شبکه‌های کامپیوتری

گزارش کار آزمایش ۵

گروه ۴

علی صدیقی ۹۷۵۲۱۳۷۸

دانیال بازمانده ۹۷۵۲۱۱۳۵

## ۱ بخش الف

در ابتدای آزمایش و به عنوان اولین قدم، پس از دانلود فایل‌های موردنظر از LMS و انتقال به ماشین مجازی با scp، ابتدا با اجرای دستور زیر، برنامه‌ها را به حالت اجرایی درمی‌آوریم:

```
chmod +x tcp/tcpclient tcp/tcpserver udp/udpclient udp/udpserver
```

سپس، با استفاده از دستور زیر، مکانیزم کنترل ازدحام TCP را به مکانیزم reno تغییر می‌دهیم.

```
sudo bash -c 'echo reno >/proc/sys/net/ipv4/tcp_congestion_control'
```

## ۲ بخش ب

در مرحله‌ی بعد، با تغییر موارد خواسته‌شده ازجمله تعریف هاست‌ها و روترها در فایل lab5\_network.py اقدام به ساخت توپولوژی موردنظر می‌کنیم که همانطور که مشاهده می‌شود، خروجی دستور pingall موفقیت‌آمیز بودن ساخت این توپولوژی را به اثبات می‌رساند.

```
mininet@mininet-vm: ~/lab5/lab5
** Adding Hosts
** Adding Switches
** Creating Links
** Modifying Link Parameters
(10,00Mbit ECN) *** Configuring hosts
h1 h2 h3 r1
*** Starting controller
c0
*** Starting 2 switches
sw1 sw2 ...
*** Configuring hosts
** Executing custom commands
** Enabling xterm for hosts only
** Running CLI
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 r1
h2 -> h1 h3 r1
h3 -> h1 h2 r1
r1 -> h1 h2 h3
*** Results: 0% dropped (12/12 received)
mininet> █
```

## ۳ بخش ب-۱

در مرحله‌ی بعد، با استفاده از دستورات زیر در دایرکتوری مربوط به UDP، یک سرور از جنس UDP در h3 بالا می‌آوریم که روی پورت 10000 گوش کند.

```
./udpserver 10000
```

## ۴ سوال ۱

با استفاده از دستور زیر، روی ماشین h1 یک کلاینت UDP اجرا می‌کنیم که برای سرور h3 داده‌ها را با نرخ 100Kbps ارسال می‌کند.

```
./udpcient 10.10.1.0 10000 100
```

"host: h1"	x	"host: h3"	x
215.3s - sent: 2692 pkts, 99.8 kbits/s		437.9s - received: 2692/ sent: 2692 pkts (loss 0.000%), 100.0 kbit/s	
216.3s - sent: 2705 pkts, 100.1 kbits/s		439.0s - received: 2705/ sent: 2705 pkts (loss 0.000%), 100.0 kbit/s	
217.4s - sent: 2718 pkts, 100.2 kbits/s		440.0s - received: 2718/ sent: 2718 pkts (loss 0.000%), 100.0 kbit/s	
218.4s - sent: 2731 pkts, 100.1 kbits/s		441.0s - received: 2731/ sent: 2731 pkts (loss 0.000%), 100.0 kbit/s	
219.4s - sent: 2744 pkts, 100.3 kbits/s		442.1s - received: 2744/ sent: 2744 pkts (loss 0.000%), 99.9 kbit/s	
220.5s - sent: 2757 pkts, 99.8 kbits/s		443.1s - received: 2757/ sent: 2757 pkts (loss 0.000%), 100.1 kbit/s	
221.5s - sent: 2770 pkts, 100.1 kbits/s		444.2s - received: 2770/ sent: 2770 pkts (loss 0.000%), 100.0 kbit/s	
222.6s - sent: 2783 pkts, 100.3 kbits/s		445.2s - received: 2783/ sent: 2783 pkts (loss 0.000%), 100.1 kbit/s	
223.6s - sent: 2796 pkts, 100.1 kbits/s		446.2s - received: 2796/ sent: 2796 pkts (loss 0.000%), 100.0 kbit/s	
224.6s - sent: 2809 pkts, 100.1 kbits/s		447.3s - received: 2809/ sent: 2809 pkts (loss 0.000%), 100.0 kbit/s	
225.7s - sent: 2822 pkts, 99.9 kbits/s		448.3s - received: 2822/ sent: 2822 pkts (loss 0.000%), 99.9 kbit/s	
226.7s - sent: 2835 pkts, 100.2 kbits/s		449.4s - received: 2835/ sent: 2835 pkts (loss 0.000%), 100.1 kbit/s	
227.8s - sent: 2848 pkts, 100.2 kbits/s		450.4s - received: 2848/ sent: 2848 pkts (loss 0.000%), 100.0 kbit/s	
228.8s - sent: 2861 pkts, 100.1 kbits/s		451.4s - received: 2861/ sent: 2861 pkts (loss 0.000%), 100.0 kbit/s	
229.8s - sent: 2874 pkts, 100.3 kbits/s		452.5s - received: 2874/ sent: 2874 pkts (loss 0.000%), 100.0 kbit/s	
230.9s - sent: 2887 pkts, 100.0 kbits/s		453.5s - received: 2887/ sent: 2887 pkts (loss 0.000%), 100.0 kbit/s	
231.9s - sent: 2900 pkts, 100.3 kbits/s		454.6s - received: 2900/ sent: 2900 pkts (loss 0.000%), 100.0 kbit/s	
233.0s - sent: 2913 pkts, 100.1 kbits/s		455.6s - received: 2913/ sent: 2913 pkts (loss 0.000%), 100.0 kbit/s	
234.0s - sent: 2926 pkts, 100.0 kbits/s		456.6s - received: 2926/ sent: 2926 pkts (loss 0.000%), 100.0 kbit/s	
235.0s - sent: 2939 pkts, 100.4 kbits/s		457.7s - received: 2939/ sent: 2939 pkts (loss 0.000%), 100.0 kbit/s	
236.1s - sent: 2952 pkts, 99.8 kbits/s		458.7s - received: 2952/ sent: 2952 pkts (loss 0.000%), 99.8 kbit/s	
237.1s - sent: 2965 pkts, 100.1 kbits/s		459.8s - received: 2965/ sent: 2965 pkts (loss 0.000%), 100.2 kbit/s	
^Cpackets sent = 2967, avg rate= 100.0kbps		packet received = 2967 / 2967 sent: 0.000% loss	

همانطور که مشاهده می‌شود، احتمال loss با این rate صفر درصد و مقدار goodput حدود 100Kbps است.

## ۵ سوال ۲

آزمایش قبلی را ۴ بار دیگر به ترتیب با نرخ‌های 1Mbps، 10Mbps، 100Mbps و 1Gbps اجرا می‌کنیم.

"host: h1"	x	"host: h3"	x
126.9s - sent: 15861 pkts, 1002.2 kbits/s		646.5s - received: 15839/ sent: 15839 pkts (loss 0.000%), 999.3 kbit/s	
127.9s - sent: 15987 pkts, 1004.2 kbits/s		647.5s - received: 15965/ sent: 15965 pkts (loss 0.000%), 1000.7 kbit/s	
128.9s - sent: 16113 pkts, 1002.1 kbits/s		648.6s - received: 16091/ sent: 16091 pkts (loss 0.000%), 999.6 kbit/s	
129.9s - sent: 16239 pkts, 1005.2 kbits/s		649.6s - received: 16217/ sent: 16217 pkts (loss 0.000%), 1000.2 kbit/s	
130.9s - sent: 16365 pkts, 1001.5 kbits/s		650.6s - received: 16343/ sent: 16343 pkts (loss 0.000%), 1000.5 kbit/s	
131.9s - sent: 16491 pkts, 1004.4 kbits/s		651.6s - received: 16469/ sent: 16469 pkts (loss 0.000%), 999.6 kbit/s	
132.9s - sent: 16617 pkts, 1003.8 kbits/s		652.6s - received: 16595/ sent: 16595 pkts (loss 0.000%), 1000.0 kbit/s	
133.9s - sent: 16743 pkts, 1005.6 kbits/s		653.6s - received: 16721/ sent: 16721 pkts (loss 0.000%), 1000.1 kbit/s	
134.9s - sent: 16869 pkts, 1001.8 kbits/s		654.6s - received: 16847/ sent: 16847 pkts (loss 0.000%), 1000.8 kbit/s	
136.0s - sent: 16995 pkts, 1004.0 kbits/s		655.6s - received: 16972/ sent: 16972 pkts (loss 0.000%), 999.6 kbit/s	
137.0s - sent: 17121 pkts, 1001.8 kbits/s		656.6s - received: 17097/ sent: 17097 pkts (loss 0.000%), 999.7 kbit/s	
138.0s - sent: 17247 pkts, 1002.6 kbits/s		657.6s - received: 17223/ sent: 17223 pkts (loss 0.000%), 1000.2 kbit/s	
139.0s - sent: 17373 pkts, 1004.6 kbits/s		658.6s - received: 17349/ sent: 17349 pkts (loss 0.000%), 1000.2 kbit/s	
140.0s - sent: 17499 pkts, 1001.9 kbits/s		659.6s - received: 17474/ sent: 17474 pkts (loss 0.000%), 999.9 kbit/s	
141.0s - sent: 17625 pkts, 1005.4 kbits/s		660.6s - received: 17600/ sent: 17600 pkts (loss 0.000%), 1000.6 kbit/s	
142.0s - sent: 17751 pkts, 1002.4 kbits/s		661.6s - received: 17726/ sent: 17726 pkts (loss 0.000%), 1000.1 kbit/s	
143.0s - sent: 17877 pkts, 1005.2 kbits/s		662.6s - received: 17851/ sent: 17851 pkts (loss 0.000%), 999.6 kbit/s	
144.0s - sent: 18003 pkts, 1002.2 kbits/s		663.6s - received: 17976/ sent: 17976 pkts (loss 0.000%), 999.9 kbit/s	
145.0s - sent: 18129 pkts, 1005.9 kbits/s		664.6s - received: 18102/ sent: 18102 pkts (loss 0.000%), 1000.6 kbit/s	
146.0s - sent: 18255 pkts, 1002.3 kbits/s		665.7s - received: 18227/ sent: 18227 pkts (loss 0.000%), 999.7 kbit/s	
147.0s - sent: 18381 pkts, 1005.1 kbits/s		666.7s - received: 18353/ sent: 18353 pkts (loss 0.000%), 1000.7 kbit/s	
148.0s - sent: 18507 pkts, 1002.5 kbits/s		667.7s - received: 18479/ sent: 18479 pkts (loss 0.000%), 998.9 kbit/s	
^Cpackets sent = 18592, avg rate=1000.0kbps		packet received = 18592 / 18592 sent: 0.000% loss	

اجرای آزمایش با نرخ 1Mbps

مجدداً احتمال loss صفر درصد به دست آمده است.

"host: h1"	"host: h3"
124.1s - sent:155176 pkts, 10005.6 kbits/s	857.6s - received:148118/ sent:155067 pkts (loss 4.4812%), 9512.8 kbit/s
125.1s - sent:156431 pkts, 10037.9 kbits/s	858.6s - received:149298/ sent:156318 pkts (loss 4.4912%), 9432.8 kbit/s
126.1s - sent:157683 pkts, 10015.3 kbits/s	859.6s - received:150496/ sent:157570 pkts (loss 4.4892%), 9576.1 kbit/s
127.1s - sent:158935 pkts, 10015.9 kbits/s	860.6s - received:151654/ sent:158820 pkts (loss 4.5122%), 9263.1 kbit/s
128.1s - sent:160186 pkts, 10004.2 kbits/s	861.6s - received:152852/ sent:160071 pkts (loss 4.5102%), 9577.1 kbit/s
129.1s - sent:161437 pkts, 10006.5 kbits/s	862.6s - received:154050/ sent:161322 pkts (loss 4.5082%), 9576.5 kbit/s
130.1s - sent:162688 pkts, 10006.5 kbits/s	863.6s - received:155211/ sent:162572 pkts (loss 4.5282%), 9286.2 kbit/s
131.1s - sent:163939 pkts, 10007.8 kbits/s	864.6s - received:156407/ sent:163823 pkts (loss 4.5272%), 9565.7 kbit/s
132.1s - sent:165190 pkts, 10005.9 kbits/s	865.6s - received:157604/ sent:165073 pkts (loss 4.5252%), 9574.4 kbit/s
133.1s - sent:166441 pkts, 10004.7 kbits/s	866.6s - received:158802/ sent:166325 pkts (loss 4.5232%), 9576.7 kbit/s
134.1s - sent:167692 pkts, 10007.2 kbits/s	867.6s - received:159999/ sent:167575 pkts (loss 4.5212%), 9575.6 kbit/s
135.1s - sent:168943 pkts, 10005.4 kbits/s	868.6s - received:161197/ sent:168826 pkts (loss 4.5192%), 9581.2 kbit/s
136.1s - sent:170194 pkts, 10007.0 kbits/s	869.6s - received:162399/ sent:170076 pkts (loss 4.5202%), 9529.3 kbit/s
137.1s - sent:171446 pkts, 10008.8 kbits/s	870.6s - received:163585/ sent:171327 pkts (loss 4.5192%), 9567.0 kbit/s
138.1s - sent:172697 pkts, 10007.1 kbits/s	871.6s - received:164781/ sent:172578 pkts (loss 4.5182%), 9566.0 kbit/s
139.1s - sent:173948 pkts, 10007.0 kbits/s	872.6s - received:165971/ sent:173828 pkts (loss 4.5202%), 9513.9 kbit/s
140.1s - sent:175200 pkts, 10008.1 kbits/s	873.6s - received:167163/ sent:175079 pkts (loss 4.5212%), 9532.8 kbit/s
141.1s - sent:176451 pkts, 10005.9 kbits/s	874.6s - received:168360/ sent:176330 pkts (loss 4.5202%), 9574.8 kbit/s
142.1s - sent:177704 pkts, 10017.4 kbits/s	875.6s - received:169557/ sent:177579 pkts (loss 4.5172%), 9575.8 kbit/s
143.1s - sent:178956 pkts, 10010.5 kbits/s	876.6s - received:170755/ sent:178831 pkts (loss 4.5162%), 9576.1 kbit/s
144.1s - sent:180208 pkts, 10012.9 kbits/s	877.6s - received:171952/ sent:180081 pkts (loss 4.5142%), 9574.7 kbit/s
145.1s - sent:181460 pkts, 10014.8 kbits/s	878.6s - received:173147/ sent:181332 pkts (loss 4.5142%), 9557.3 kbit/s
^Cpackets sent = 181907, avg rate=9399.5kbps	
root@mininet-vm:/home/mininet/lab5/lab5/udp#	
packet received = 173699 / 181907 sent: 4.512% loss	

## اجرای آزمایش با نرخ 10Mbps

احتمال loss افزایش پیدا کرده و به 4.5 درصد رسیده است.

"host: h1"	"host: h3"
123.1s - sent:1536555 pkts, 99927.0 kbits/s	1039.5s - received:146512/ sent:1540743 pkts (loss 90.4912%), 9562.2 kbit/s
124.1s - sent:1549053 pkts, 99981.9 kbits/s	1040.5s - received:147708/ sent:1553228 pkts (loss 90.4902%), 9567.4 kbit/s
125.1s - sent:1561544 pkts, 99926.9 kbits/s	1041.5s - received:148904/ sent:1565714 pkts (loss 90.4902%), 9565.7 kbit/s
126.1s - sent:1574037 pkts, 99941.4 kbits/s	1042.5s - received:150102/ sent:1578207 pkts (loss 90.4892%), 9576.3 kbit/s
127.1s - sent:1586530 pkts, 99932.0 kbits/s	1043.5s - received:151298/ sent:1590635 pkts (loss 90.4892%), 9565.1 kbit/s
128.1s - sent:1599033 pkts, 100022.4 kbits/s	1044.5s - received:152496/ sent:1603187 pkts (loss 90.4882%), 9576.6 kbit/s
129.1s - sent:1611538 pkts, 100032.9 kbits/s	1045.5s - received:153693/ sent:1615676 pkts (loss 90.4872%), 9571.5 kbit/s
130.1s - sent:1624044 pkts, 100039.0 kbits/s	1046.5s - received:154874/ sent:1628164 pkts (loss 90.4882%), 9444.4 kbit/s
131.1s - sent:1636562 pkts, 100110.0 kbits/s	1047.5s - received:156071/ sent:1640655 pkts (loss 90.4872%), 9570.4 kbit/s
132.1s - sent:1649066 pkts, 100026.7 kbits/s	1048.5s - received:157267/ sent:1653148 pkts (loss 90.4872%), 9560.6 kbit/s
133.1s - sent:1661564 pkts, 99972.4 kbits/s	1049.5s - received:158463/ sent:1665636 pkts (loss 90.4862%), 9564.7 kbit/s
134.1s - sent:1674057 pkts, 99933.2 kbits/s	1050.5s - received:159658/ sent:1678120 pkts (loss 90.4862%), 9559.2 kbit/s
135.1s - sent:1686557 pkts, 99995.6 kbits/s	1051.5s - received:160855/ sent:1690611 pkts (loss 90.4852%), 9570.7 kbit/s
136.1s - sent:1699049 pkts, 99929.9 kbits/s	1052.5s - received:162052/ sent:1703105 pkts (loss 90.4852%), 9568.5 kbit/s
137.1s - sent:1711540 pkts, 99923.4 kbits/s	1053.5s - received:163244/ sent:1715591 pkts (loss 90.4852%), 9533.1 kbit/s
138.1s - sent:1724035 pkts, 99947.0 kbits/s	1054.5s - received:164441/ sent:1728084 pkts (loss 90.4842%), 9569.1 kbit/s
139.1s - sent:1736527 pkts, 99930.4 kbits/s	1055.5s - received:165638/ sent:1740565 pkts (loss 90.4842%), 9574.3 kbit/s
140.1s - sent:1749020 pkts, 99931.5 kbits/s	1056.5s - received:166836/ sent:1753062 pkts (loss 90.4832%), 9576.4 kbit/s
141.1s - sent:1761526 pkts, 100040.1 kbits/s	1057.5s - received:168034/ sent:1765551 pkts (loss 90.4832%), 9579.9 kbit/s
142.1s - sent:1774036 pkts, 100076.2 kbits/s	1058.5s - received:169231/ sent:1778036 pkts (loss 90.4822%), 9574.1 kbit/s
143.1s - sent:1786525 pkts, 99909.8 kbits/s	1059.5s - received:170427/ sent:1790526 pkts (loss 90.4822%), 9563.6 kbit/s
144.1s - sent:1799018 pkts, 99937.0 kbits/s	1060.5s - received:171624/ sent:1803011 pkts (loss 90.4812%), 9574.2 kbit/s
^Cpackets sent = 1807359, avg rate=10868.2kbps	
root@mininet-vm:/home/mininet/lab5/lab5/udp#	
packet received = 172041 / 1807350 sent: 90.481% loss	

## اجرای آزمایش با نرخ 100Mbps

احتمال loss افزایش پیدا کرده و به 90 درصد رسیده است.

"host: h1"	"host: h3"
124.1s - sent:1654246 pkts, 997718.3 kbits/s	1227.7s - received:156769/ sent:16539266 pkts (loss 99.0522%), 9573.9 kbit/s
125.1s - sent:1666638 pkts, 997534.1 kbits/s	1228.7s - received:157966/ sent:16662741 pkts (loss 99.0522%), 9576.4 kbit/s
126.1s - sent:16790075 pkts, 997092.0 kbits/s	1229.7s - received:159163/ sent:16786141 pkts (loss 99.0522%), 9572.9 kbit/s
127.1s - sent:16913498 pkts, 997380.9 kbits/s	1230.7s - received:160355/ sent:16909597 pkts (loss 99.0522%), 9528.8 kbit/s
128.1s - sent:17036907 pkts, 997272.0 kbits/s	1231.7s - received:161553/ sent:17033049 pkts (loss 99.0522%), 9577.8 kbit/s
129.1s - sent:17160288 pkts, 997045.9 kbits/s	1232.7s - received:162751/ sent:17156505 pkts (loss 99.0512%), 9576.4 kbit/s
130.1s - sent:17283708 pkts, 997359.1 kbits/s	1233.7s - received:163949/ sent:17279938 pkts (loss 99.0512%), 9571.2 kbit/s
131.1s - sent:17407489 pkts, 990244.9 kbits/s	1234.7s - received:164738/ sent:17493809 pkts (loss 99.0502%), 9384.5 kbit/s
132.1s - sent:17530925 pkts, 987486.8 kbits/s	1235.7s - received:165937/ sent:17613851 pkts (loss 99.0502%), 9590.8 kbit/s
133.1s - sent:17654349 pkts, 987390.1 kbits/s	1236.7s - received:167194/ sent:17737270 pkts (loss 99.0572%), 9571.3 kbit/s
134.1s - sent:17777789 pkts, 987519.1 kbits/s	1237.7s - received:168392/ sent:17860727 pkts (loss 99.0572%), 9577.1 kbit/s
135.1s - sent:17901226 pkts, 987496.0 kbits/s	1238.7s - received:169589/ sent:17984119 pkts (loss 99.0572%), 9574.1 kbit/s
136.1s - sent:18024656 pkts, 987438.1 kbits/s	1239.7s - received:170786/ sent:18107506 pkts (loss 99.0572%), 9573.9 kbit/s
137.1s - sent:18148089 pkts, 987464.0 kbits/s	1240.7s - received:171983/ sent:18230902 pkts (loss 99.0572%), 9573.7 kbit/s
138.1s - sent:18271518 pkts, 987430.8 kbits/s	1241.7s - received:173180/ sent:18354335 pkts (loss 99.0562%), 9570.7 kbit/s
139.1s - sent:18394961 pkts, 987543.1 kbits/s	1242.7s - received:174377/ sent:18477708 pkts (loss 99.0562%), 9575.3 kbit/s
140.1s - sent:18518393 pkts, 987393.9 kbits/s	1243.7s - received:175574/ sent:18601071 pkts (loss 99.0562%), 9575.9 kbit/s
141.1s - sent:18641832 pkts, 987431.0 kbits/s	1244.7s - received:176772/ sent:18724527 pkts (loss 99.0562%), 9577.2 kbit/s
142.1s - sent:18765261 pkts, 990308.2 kbits/s	1245.7s - received:177969/ sent:18847892 pkts (loss 99.0562%), 9575.8 kbit/s
143.1s - sent:18889180 pkts, 988404.8 kbits/s	1246.7s - received:179165/ sent:18971195 pkts (loss 99.0562%), 9565.6 kbit/s
144.1s - sent:19012746 pkts, 988505.4 kbits/s	1247.7s - received:180362/ sent:19094659 pkts (loss 99.0552%), 9575.3 kbit/s
145.1s - sent:19136173 pkts, 987348.7 kbits/s	1248.7s - received:181560/ sent:19218117 pkts (loss 99.0552%), 9576.8 kbit/s
^Cpackets sent = 19243106, avg rate=4319.7kbps	
root@mininet-vm:/home/mininet/lab5/lab5/udp#	
packet received = 181802 / 19243000 sent: 99.055% loss	

## اجرای آزمایش با نرخ 1Gbps

احتمال loss افزایش پیدا کرده و به 99 درصد رسیده است.

همانطور که در تصاویر مشهود است، به ازای نرخ 10Mbps و بیشتر، احتمال loss بالای یک درصد به دست آمده است.

دلیل اصلی این قضیه را در کد پایتون می‌توان در دستور زیر دانست.

```
link_r1sw2.intf1.config(bw=10, enable_red=True, enable_ecn=True)
```

پارامتر bw مخفف عبارت bandwidth به معنای پهنای باند است که برحسب Mbps داده می‌شود. با توجه به اینکه مقدار 10Mbps را به عنوان پهنای باند داریم، پس ارسال داده‌هایی با نرخ بالاتر از این مقدار باعث packet loss خواهند شد.

## ۶ سوال ۳

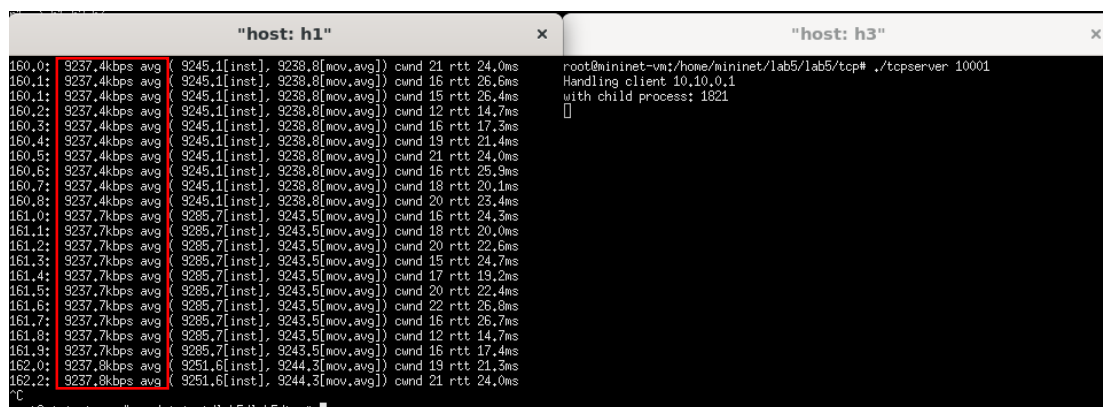
در مرحله‌ی بعد، با استفاده از دستورات زیر در دایرکتوری مربوط به TCP، یک سرور از جنس UDP در h3 بالا می‌آوریم که روی پورت 10001 گوش کند.

```
./tcpserver 10001
```

با استفاده از دستور زیر، روی ماشین h1 یک کلاینت UDP اجرا می‌کنیم که برای سرور h3 داده‌ها را ارسال می‌کند.

```
./udpclient 10.10.1.0 10001
```

مقداری صبر می‌کنیم تا به حالت نسبتاً پایداری برسیم.



مقدار goodput برای این ارتباط به صورت میانگین 9237Kbps می‌باشد.

## ۷ بخش ب-۲

در این مرحله اقدام به محدودسازی پهنای باند اینترفیس eth1 به 3Mbps می‌کنیم. این کار را با استفاده از دستور زیر انجام می‌دهیم.

```
link.r1sw2.intf1.config(bw=3)
```

```

mininet@mininet-vm: ~/lab5/lab5
GNU nano 4.8 lab5_network.py Modified
Default parameters for links:
bw = None,
delay = None,
jitter = None,
loss = None,
disable_gro = True,
speedup = 0,
use_hfsc = False,
use_tbf = False,
latency_ms = None,
enable_ecn = False,
enable_red = False,
max_queue_size = None
.....
link_r1su2.intf1.config( bw=3, enable_red=True, enable_ecn=True)
net.start()

```

توپولوژی قبلی را clean-up کرده و مجدداً فایل پایتون را اجرا می‌کنیم تا تغییرات اعمال شود.

## ۸ سوال ۴

همانطور که مشاهده می‌شود، در ستون length مقدار فریم‌های Ethernet مقدار 1042 بایت است که با مقدار تئوری همخوانی دارد.

The image shows a Wireshark capture of network traffic. The packet list on the right shows several UDP packets from 10.10.0.1 to 10.10.1.3. The length of each packet is 1042 bytes. The packet details pane shows the structure of a UDP packet: Ethernet II, Internet Protocol Version 4, and User Datagram Protocol.

## ۹ سوال ۵

برای محاسبه‌ی حداکثر مقدار قابل دستیابی برای گزردهی داده‌های کاربردی (goodput) داریم:

$$goodput = bw \times \frac{1000}{1042} = 3 \times 0.96 = 2.88 \text{ Mbps}$$

## ۱۰ سوال ۶

پس از راه‌اندازی مجدد سرور UDP با پورت 10000 روی h3 و کلاینت UDP روی h1 با نرخ 100Kbps داریم:

"host: h1"	"host: h3"
9.4s - sent: 118 pkts, 100.1 kbits/s	31.1s - received: 118/ sent: 118 pkts (loss 0.000%), 100.0 kbit/s
10.4s - sent: 131 pkts, 100.2 kbits/s	32.2s - received: 131/ sent: 131 pkts (loss 0.000%), 100.0 kbit/s
11.4s - sent: 144 pkts, 100.3 kbits/s	33.2s - received: 144/ sent: 144 pkts (loss 0.000%), 100.0 kbit/s
12.5s - sent: 157 pkts, 99.8 kbits/s	34.3s - received: 157/ sent: 157 pkts (loss 0.000%), 100.0 kbit/s
13.5s - sent: 170 pkts, 100.1 kbits/s	35.3s - received: 170/ sent: 170 pkts (loss 0.000%), 100.0 kbit/s
14.6s - sent: 183 pkts, 100.0 kbits/s	36.3s - received: 183/ sent: 183 pkts (loss 0.000%), 100.0 kbit/s
15.6s - sent: 196 pkts, 100.3 kbits/s	37.4s - received: 196/ sent: 196 pkts (loss 0.000%), 100.0 kbit/s
16.6s - sent: 209 pkts, 100.0 kbits/s	38.4s - received: 209/ sent: 209 pkts (loss 0.000%), 100.0 kbit/s
17.7s - sent: 222 pkts, 99.9 kbits/s	39.5s - received: 222/ sent: 222 pkts (loss 0.000%), 100.0 kbit/s
18.7s - sent: 235 pkts, 100.2 kbits/s	40.5s - received: 235/ sent: 235 pkts (loss 0.000%), 99.9 kbit/s
19.8s - sent: 248 pkts, 99.8 kbits/s	41.5s - received: 248/ sent: 248 pkts (loss 0.000%), 100.1 kbit/s
20.8s - sent: 261 pkts, 100.1 kbits/s	42.6s - received: 261/ sent: 261 pkts (loss 0.000%), 100.0 kbit/s
21.8s - sent: 274 pkts, 100.3 kbits/s	43.6s - received: 274/ sent: 274 pkts (loss 0.000%), 99.9 kbit/s
22.9s - sent: 287 pkts, 99.8 kbits/s	44.7s - received: 287/ sent: 287 pkts (loss 0.000%), 100.1 kbit/s
23.9s - sent: 300 pkts, 100.1 kbits/s	45.7s - received: 300/ sent: 300 pkts (loss 0.000%), 100.0 kbit/s
25.0s - sent: 313 pkts, 100.2 kbits/s	46.7s - received: 313/ sent: 313 pkts (loss 0.000%), 100.0 kbit/s
26.0s - sent: 326 pkts, 100.3 kbits/s	47.8s - received: 326/ sent: 326 pkts (loss 0.000%), 100.0 kbit/s
27.0s - sent: 339 pkts, 100.1 kbits/s	48.8s - received: 339/ sent: 339 pkts (loss 0.000%), 100.1 kbit/s
28.1s - sent: 352 pkts, 100.0 kbits/s	49.9s - received: 352/ sent: 352 pkts (loss 0.000%), 100.0 kbit/s
29.1s - sent: 365 pkts, 100.0 kbits/s	50.9s - received: 365/ sent: 365 pkts (loss 0.000%), 100.0 kbit/s
30.2s - sent: 378 pkts, 100.2 kbits/s	51.9s - received: 378/ sent: 378 pkts (loss 0.000%), 99.8 kbit/s
31.2s - sent: 391 pkts, 100.0 kbits/s	53.0s - received: 391/ sent: 391 pkts (loss 0.000%), 100.2 kbit/s
^Cpackets sent = 396, avg rate = 100.0kbps	packet received = 396 / 396 sent: 0.000% loss

همانطور که مشاهده می‌شود، مقدار loss صفر و مقدار goodput حدود 100Kbps می‌باشد.

## ۱۱ سوال ۷

پس از اجرای عملیات بالا در نرخ‌های 3Mbps و 10Mbps داریم:

```

"host: h1" x "host: h3" x
55.1s - sent: 20675 pkts, 3001.4 kbits/s
56.1s - sent: 21061 pkts, 3002.9 kbits/s
57.1s - sent: 21427 pkts, 3006.8 kbits/s
58.1s - sent: 21803 pkts, 3002.1 kbits/s
59.1s - sent: 22179 pkts, 3002.7 kbits/s
60.1s - sent: 22555 pkts, 3001.4 kbits/s
61.1s - sent: 22930 pkts, 2999.9 kbits/s
62.1s - sent: 23306 pkts, 3004.6 kbits/s
63.2s - sent: 23682 pkts, 3004.3 kbits/s
64.2s - sent: 24057 pkts, 2999.5 kbits/s
65.2s - sent: 24433 pkts, 3005.8 kbits/s
66.2s - sent: 24809 pkts, 3001.6 kbits/s
67.2s - sent: 25184 pkts, 2999.5 kbits/s
68.2s - sent: 25560 pkts, 3004.8 kbits/s
69.2s - sent: 25936 pkts, 3000.7 kbits/s
70.2s - sent: 26312 pkts, 3003.2 kbits/s
71.2s - sent: 26688 pkts, 3005.3 kbits/s
72.2s - sent: 27064 pkts, 3000.3 kbits/s
73.2s - sent: 27440 pkts, 3001.5 kbits/s
74.2s - sent: 27816 pkts, 3001.9 kbits/s
75.2s - sent: 28192 pkts, 3006.0 kbits/s
76.2s - sent: 28567 pkts, 2999.7 kbits/s
^Cpackets sent = 28642, avg rate=2936.8kbps
root@mininet-vml:/home/mininet/lab5/lab5/udp#

136.8s - received: 19724/ sent: 20628 pkts (loss 4.382%), 2955.7 kbit/s
137.8s - received: 20082/ sent: 21003 pkts (loss 4.388%), 2956.4 kbit/s
138.8s - received: 20440/ sent: 21379 pkts (loss 4.392%), 2957.0 kbit/s
139.8s - received: 20798/ sent: 21755 pkts (loss 4.398%), 2950.2 kbit/s
140.8s - received: 21156/ sent: 22130 pkts (loss 4.401%), 2957.2 kbit/s
141.8s - received: 21513/ sent: 22506 pkts (loss 4.412%), 2955.4 kbit/s
142.8s - received: 21872/ sent: 22882 pkts (loss 4.414%), 2968.5 kbit/s
143.8s - received: 22229/ sent: 23256 pkts (loss 4.416%), 2951.5 kbit/s
144.8s - received: 22588/ sent: 23633 pkts (loss 4.422%), 2964.0 kbit/s
145.8s - received: 22945/ sent: 24007 pkts (loss 4.424%), 2948.6 kbit/s
146.8s - received: 23302/ sent: 24384 pkts (loss 4.437%), 2950.7 kbit/s
147.8s - received: 23659/ sent: 24769 pkts (loss 4.443%), 2955.1 kbit/s
148.8s - received: 24016/ sent: 25134 pkts (loss 4.448%), 2952.2 kbit/s
149.8s - received: 24374/ sent: 25511 pkts (loss 4.457%), 2957.2 kbit/s
150.8s - received: 24732/ sent: 25887 pkts (loss 4.462%), 2957.2 kbit/s
151.8s - received: 25089/ sent: 26262 pkts (loss 4.467%), 2954.8 kbit/s
152.8s - received: 25446/ sent: 26637 pkts (loss 4.471%), 2953.1 kbit/s
153.8s - received: 25803/ sent: 27012 pkts (loss 4.476%), 2950.5 kbit/s
154.8s - received: 26161/ sent: 27389 pkts (loss 4.484%), 2958.3 kbit/s
155.8s - received: 26518/ sent: 27764 pkts (loss 4.488%), 2955.8 kbit/s
156.8s - received: 26876/ sent: 28140 pkts (loss 4.492%), 2951.1 kbit/s
157.8s - received: 27234/ sent: 28515 pkts (loss 4.492%), 2958.5 kbit/s
packet received = 27333 / 28642 sent: 4.500% loss

```

## اجرای آزمایش با نرخ 3Mbps

همانطور که مشاهده می‌شود، مقدار goodput حدود بازه‌ی 2850-2860 است که بسیار به عددی که به دست آوردیم (2.88 Mbps) نزدیک است و تقریباً همخوانی دارد چون مقدار packet loss کم است.

```

"host: h1" x "host: h3" x
43.1s - sent: 53849 pkts, 10011.1 kbits/s
44.1s - sent: 55101 pkts, 10009.6 kbits/s
45.1s - sent: 56354 pkts, 10018.5 kbits/s
46.1s - sent: 57608 pkts, 10026.2 kbits/s
47.1s - sent: 58860 pkts, 10015.8 kbits/s
48.1s - sent: 60111 pkts, 10007.1 kbits/s
49.1s - sent: 61363 pkts, 10010.6 kbits/s
50.1s - sent: 62614 pkts, 10007.8 kbits/s
51.1s - sent: 63865 pkts, 10006.6 kbits/s
52.1s - sent: 65117 pkts, 10008.1 kbits/s
53.1s - sent: 66368 pkts, 10007.6 kbits/s
54.1s - sent: 67619 pkts, 10006.0 kbits/s
55.1s - sent: 68871 pkts, 10008.9 kbits/s
56.1s - sent: 70123 pkts, 10010.0 kbits/s
57.1s - sent: 71379 pkts, 10044.5 kbits/s
58.1s - sent: 72632 pkts, 10017.6 kbits/s
59.1s - sent: 73884 pkts, 10009.6 kbits/s
60.1s - sent: 75136 pkts, 10008.8 kbits/s
61.1s - sent: 76388 pkts, 10008.5 kbits/s
62.1s - sent: 77640 pkts, 10008.0 kbits/s
63.1s - sent: 78891 pkts, 10006.2 kbits/s
64.1s - sent: 80143 pkts, 10015.4 kbits/s
^Cpackets sent = 80233, avg rate=9985.4kbps
root@mininet-vml:/home/mininet/lab5/lab5/udp#

221.2s - received: 14911/ sent: 52872 pkts (loss 71.798%), 2891.4 kbit/s
222.2s - received: 15271/ sent: 54123 pkts (loss 71.785%), 2878.0 kbit/s
223.2s - received: 15631/ sent: 55374 pkts (loss 71.772%), 2879.1 kbit/s
224.2s - received: 15994/ sent: 57358 pkts (loss 72.347%), 1185.5 kbit/s
225.8s - received: 16225/ sent: 58995 pkts (loss 72.510%), 2882.1 kbit/s
226.8s - received: 16595/ sent: 59846 pkts (loss 72.287%), 2879.2 kbit/s
227.8s - received: 16945/ sent: 61087 pkts (loss 72.353%), 2878.9 kbit/s
228.8s - received: 17305/ sent: 62347 pkts (loss 72.244%), 2879.5 kbit/s
229.8s - received: 17665/ sent: 63598 pkts (loss 72.224%), 2879.2 kbit/s
230.8s - received: 18025/ sent: 64848 pkts (loss 72.204%), 2879.2 kbit/s
231.8s - received: 18385/ sent: 66099 pkts (loss 72.186%), 2875.8 kbit/s
232.8s - received: 18745/ sent: 67351 pkts (loss 72.168%), 2879.2 kbit/s
233.8s - received: 19105/ sent: 68601 pkts (loss 72.151%), 2879.9 kbit/s
234.8s - received: 19465/ sent: 69852 pkts (loss 72.134%), 2873.0 kbit/s
235.8s - received: 19825/ sent: 71105 pkts (loss 72.119%), 2877.9 kbit/s
236.8s - received: 20186/ sent: 72359 pkts (loss 72.103%), 2880.1 kbit/s
237.8s - received: 20543/ sent: 73610 pkts (loss 72.092%), 2850.1 kbit/s
238.8s - received: 20903/ sent: 74863 pkts (loss 72.078%), 2877.6 kbit/s
239.8s - received: 21264/ sent: 76117 pkts (loss 72.064%), 2880.7 kbit/s
240.8s - received: 21624/ sent: 77367 pkts (loss 72.050%), 2877.3 kbit/s
241.8s - received: 21984/ sent: 78619 pkts (loss 72.037%), 2879.2 kbit/s
242.8s - received: 22344/ sent: 79863 pkts (loss 72.024%), 2879.2 kbit/s
packet received = 22448 / 80231 sent: 72.021% loss

```

## اجرای آزمایش با نرخ 10Mbps

همانطور که مشاهده می‌شود، مقدار goodput حدود بازه‌ی 2870-2880 است که اگر از نظر تئوری بخواهیم محاسبه کنیم، داریم:

$$goodput = bw \times \frac{1000}{1042} = 10 \times 0.96 = 9.6 \text{ Mbps}$$

عددی که به طور تئوری به دست آمده است، بسیار با چیزی که در عمل می‌بینیم فاصله دارد که علت آن این است که حجم بسیار زیادی از داده‌ها و بسته‌ها loss می‌شوند. (نرخ packet loss حدود ۷۲ درصد است.)



با گوش دادن به بسته‌ها در سمت سرور درستی فرضیه را به طور عملی اطمینان پیدا می‌کنیم. همانطور که در تصاویر زیر مشاهده می‌شود، مقدار هدر IP برابر 20 بایت، مقدار هدر اترنت برابر 14 بایت و مقدار هدر TCP برابر 32 بایت است.

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol
2088	8.300412296	10.10.1.3	10.10.0.1	TCP
2089	8.308457832	10.10.0.1	10.10.1.3	TCP
2090	8.308477971	10.10.1.3	10.10.0.1	TCP
2091	8.316949954	10.10.0.1	10.10.1.3	TCP
2092	8.316977265	10.10.1.3	10.10.0.1	TCP
2093	8.325170747	10.10.0.1	10.10.1.3	TCP
2094	8.325199665	10.10.1.3	10.10.0.1	TCP
2095	8.333108413	10.10.0.1	10.10.1.3	TCP
2096	8.333137103	10.10.1.3	10.10.0.1	TCP
2097	8.340809881	10.10.0.1	10.10.1.3	TCP
2098	8.340842987	10.10.1.3	10.10.0.1	TCP
2099	8.349099362	10.10.0.1	10.10.1.3	TCP
2100	8.349164538	10.10.1.3	10.10.0.1	TCP
2101	8.356919434	10.10.0.1	10.10.1.3	TCP
2102	8.356982568	10.10.1.3	10.10.0.1	TCP
2103	8.357101570	10.10.0.1	10.10.1.3	TCP
2104	8.360972570	10.10.0.1	10.10.1.3	TCP

Frame 1: 2962 bytes on wire (23696 bits), 2962 bytes captured (23696 Ethernet II, Src: f6:f6:eb:fb:db:ec (f6:f6:eb:fb:db:ec), Dst: 86:aa:00:00:00:00)
Internet Protocol Version 4, Src: 10.10.0.1, Dst: 10.10.1.3
Transmission Control Protocol, Src Port: 55840, Dst Port: 10001, Seq: 2896
Data (2896 bytes)

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol
2088	8.300412296	10.10.1.3	10.10.0.1	TCP
2089	8.308457832	10.10.0.1	10.10.1.3	TCP
2090	8.308477971	10.10.1.3	10.10.0.1	TCP
2091	8.316949954	10.10.0.1	10.10.1.3	TCP
2092	8.316977265	10.10.1.3	10.10.0.1	TCP
2093	8.325170747	10.10.0.1	10.10.1.3	TCP
2094	8.325199665	10.10.1.3	10.10.0.1	TCP
2095	8.333108413	10.10.0.1	10.10.1.3	TCP
2096	8.333137103	10.10.1.3	10.10.0.1	TCP
2097	8.340809881	10.10.0.1	10.10.1.3	TCP
2098	8.340842987	10.10.1.3	10.10.0.1	TCP
2099	8.349099362	10.10.0.1	10.10.1.3	TCP
2100	8.349164538	10.10.1.3	10.10.0.1	TCP
2101	8.356919434	10.10.0.1	10.10.1.3	TCP
2102	8.356982568	10.10.1.3	10.10.0.1	TCP
2103	8.357101570	10.10.0.1	10.10.1.3	TCP
2104	8.360972570	10.10.0.1	10.10.1.3	TCP

Frame 1: 2962 bytes on wire (23696 bits), 2962 bytes captured (23696 Ethernet II, Src: f6:f6:eb:fb:db:ec (f6:f6:eb:fb:db:ec), Dst: 86:aa:00:00:00:00)
Internet Protocol Version 4, Src: 10.10.0.1, Dst: 10.10.1.3
Transmission Control Protocol, Src Port: 55840, Dst Port: 10001, Seq: 2896
Data (2896 bytes)

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol
2088	8.300412296	10.10.1.3	10.10.0.1	TCP
2089	8.308457832	10.10.0.1	10.10.1.3	TCP
2090	8.308477971	10.10.1.3	10.10.0.1	TCP
2091	8.316949954	10.10.0.1	10.10.1.3	TCP
2092	8.316977265	10.10.1.3	10.10.0.1	TCP
2093	8.325170747	10.10.0.1	10.10.1.3	TCP
2094	8.325199665	10.10.1.3	10.10.0.1	TCP
2095	8.333108413	10.10.0.1	10.10.1.3	TCP
2096	8.333137103	10.10.1.3	10.10.0.1	TCP
2097	8.340809881	10.10.0.1	10.10.1.3	TCP
2098	8.340842987	10.10.1.3	10.10.0.1	TCP
2099	8.349099362	10.10.0.1	10.10.1.3	TCP
2100	8.349164538	10.10.1.3	10.10.0.1	TCP
2101	8.356919434	10.10.0.1	10.10.1.3	TCP
2102	8.356982568	10.10.1.3	10.10.0.1	TCP
2103	8.357101570	10.10.0.1	10.10.1.3	TCP
2104	8.360972570	10.10.0.1	10.10.1.3	TCP

Frame 1: 2962 bytes on wire (23696 bits), 2962 bytes captured (23696 Ethernet II, Src: f6:f6:eb:fb:db:ec (f6:f6:eb:fb:db:ec), Dst: 86:aa:00:00:00:00)
Internet Protocol Version 4, Src: 10.10.0.1, Dst: 10.10.1.3
Transmission Control Protocol, Src Port: 55

اما این قضیه در مورد data صدق نمی کند و مشاهده می کنیم مقدار Data برابر 2896 بایت می باشد.

The figure shows three panels of Wireshark's packet details:

- Ethernet II**: Shows Source MAC as 08:00:2B:01:02:00 and Destination MAC as 08:00:2B:01:02:00.
- Internet Protocol Version 4**: Shows Source IP as 10.10.0.1 and Destination IP as 10.10.0.1.
- Transmission Control Protocol**: Shows Src Port as 55840 and Dst Port as 10001.

The packet bytes panel at the bottom displays the raw data in hexadecimal and ASCII format, starting with 2d bf 00 00 00 00 00 00 00 00 00 00 00 00 00 00.



```
ethtool -K h1-eth0 tx off sg off tso off
```

The screenshot shows the Wireshark interface with a packet capture running. The top menu bar includes File, Edit, View, Go, Capture, Analyze, Statistics, and Tools. The toolbar contains icons for starting/stopping capture, saving, opening, zooming, and other functions.

The main window displays a list of captured packets:

No.	Time	Source	Destination
1	0.000000000	10.10.0.1	10.10.0.1
2	0.003979019	10.10.0.1	10.10.0.1
3	0.003999810	10.10.1.3	10.10.0.1
4	0.008780823	10.10.0.1	10.10.0.1
5	0.012695351	10.10.0.1	10.10.0.1
6	0.012714201	10.10.1.3	10.10.0.1
7	0.016583946	10.10.0.1	10.10.0.1
8	0.020492989	10.10.0.1	10.10.0.1
9	0.020502952	10.10.1.3	10.10.0.1
10	0.024394028	10.10.0.1	10.10.0.1
11	0.028315338	10.10.0.1	10.10.0.1
12	0.028332859	10.10.1.3	10.10.0.1
13	0.032198454	10.10.0.1	10.10.0.1
14	0.036217710	10.10.0.1	10.10.0.1
15	0.036226764	10.10.1.3	10.10.0.1
16	0.040245411	10.10.0.1	10.10.0.1
17	0.044918497	10.10.0.1	10.10.0.1

Below the packet list, the packet details pane for the selected packet (Frame 10) shows the following layers:

- Ethernet II, Src: f6:f6:eb:fb:db:ec (f6:f6:eb:fb:db:ec), Dst: 01:00:5e:00:00:00 (01:00:5e:00:00:00)
- Internet Protocol Version 4, Src: 10.10.0.1, Dst: 10.10.0.1
- Transmission Control Protocol, Src Port: 55842, Dst Port: 55842
- Data (1448 bytes)

The packet bytes pane at the bottom shows the raw data in hexadecimal and ASCII format. The first few bytes are 00 04 99 05, followed by several zero bytes.

برای محاسبه‌ی مقدار goodput به صورت تئوری در پروتکل TCP به این صورت باید عمل کنیم که مقدار پهنای باند را در حاصل تقسیم اندازه‌ی داده‌های کاربردی بر اندازه‌ی کل فریم اترنتی به دست آوریم. همانطور که می‌دانیم، اندازه‌ی داده‌های کاربردی 1448 و اندازه‌ی کل فریم اترنتی 1514 بایت به دست آمده است. با در نظر گرفتن 3Mbps به عنوان پهنای باند داریم:

$$goodput = bw \times \frac{1448}{1514} = 3 \times 0.956 = 2.86 \text{ Mbps}$$

پس از راه اندازی مجدد سرور TCP با پورت 10001 روی h3 و کلاینت TCP روی h1 داریم:

"host: h1"										"host: h3"									
38.1:	2786.3kbps	avg	(2779.9[inst], 2786.4[mov,avg])	cwnd	19	rtt	73.6ms			239.8s	-	received:	21264/	sent:	76117	pkts	(loss 72.064%),	2880.7	kbit/s
38.4:	2786.8kbps	avg	(2803.7[inst], 2788.1[mov,avg])	cwnd	21	rtt	80.4ms			240.8s	-	received:	21624/	sent:	77367	pkts	(loss 72.050%),	2877.3	kbit/s
38.8:	2786.8kbps	avg	(2803.7[inst], 2788.1[mov,avg])	cwnd	16	rtt	76.1ms			241.8s	-	received:	21984/	sent:	78619	pkts	(loss 72.037%),	2879.2	kbit/s
39.2:	2786.8kbps	avg	(2803.7[inst], 2788.1[mov,avg])	cwnd	19	rtt	71.2ms			242.8s	-	received:	22344/	sent:	79869	pkts	(loss 72.024%),	2879.2	kbit/s
39.5:	2786.7kbps	avg	(2784.5[inst], 2787.7[mov,avg])	cwnd	20	rtt	79.0ms			packet received = 22448 / 80231 sent: 72.021% loss									
39.9:	2786.7kbps	avg	(2784.5[inst], 2787.7[mov,avg])	cwnd	15	rtt	82.2ms			^C									
40.3:	2786.7kbps	avg	(2784.5[inst], 2787.7[mov,avg])	cwnd	18	rtt	72.3ms			root@mininet-virtual-machine:~/mininet/lab5/lab5# cd ..									
40.6:	2787.0kbps	avg	(2798.0[inst], 2788.8[mov,avg])	cwnd	20	rtt	80.5ms			root@mininet-virtual-machine:~/mininet/lab5/lab5# ls									
41.1:	2787.0kbps	avg	(2798.0[inst], 2788.8[mov,avg])	cwnd	15	rtt	84.4ms			lab5_network.py tcp udp									
41.3:	2787.0kbps	avg	(2798.0[inst], 2788.8[mov,avg])	cwnd	18	rtt	69.7ms			root@mininet-virtual-machine:~/mininet/lab5/lab5# cd ..									
41.7:	2787.0kbps	avg	(2786.8[inst], 2788.6[mov,avg])	cwnd	20	rtt	78.4ms			root@mininet-virtual-machine:~/mininet/lab5# ls									
42.1:	2787.0kbps	avg	(2786.8[inst], 2788.6[mov,avg])	cwnd	22	rtt	84.0ms			lab5									
42.4:	2787.0kbps	avg	(2786.8[inst], 2788.6[mov,avg])	cwnd	17	rtt	65.6ms			root@mininet-virtual-machine:~/mininet/lab5# cd lab5/									
42.8:	2787.4kbps	avg	(2802.5[inst], 2790.0[mov,avg])	cwnd	19	rtt	75.3ms			root@mininet-virtual-machine:~/mininet/lab5/lab5# ls									
43.2:	2787.4kbps	avg	(2802.5[inst], 2790.0[mov,avg])	cwnd	21	rtt	81.9ms			lab5_network.py tcp udp									
43.5:	2787.4kbps	avg	(2802.5[inst], 2790.0[mov,avg])	cwnd	16	rtt	71.1ms			root@mininet-virtual-machine:~/mininet/lab5/lab5# cd tcp/									
43.9:	2787.7kbps	avg	(2800.3[inst], 2791.0[mov,avg])	cwnd	19	rtt	71.9ms			root@mininet-virtual-machine:~/mininet/lab5/lab5/tcp# ls									
44.3:	2787.7kbps	avg	(2800.3[inst], 2791.0[mov,avg])	cwnd	21	rtt	80.3ms			Makefile tcpclient tcpclient.c tcpserver tcpserver.c									
44.6:	2787.7kbps	avg	(2800.3[inst], 2791.0[mov,avg])	cwnd	15	rtt	82.2ms			root@mininet-virtual-machine:~/mininet/lab5/lab5/tcp# ./tcpserver 10001									
45.0:	2787.6kbps	avg	(2782.8[inst], 2790.2[mov,avg])	cwnd	18	rtt	76.4ms			Handling client 10.10.0.1									
45.4:	2787.6kbps	avg	(2782.8[inst], 2790.2[mov,avg])	cwnd	20	rtt	80.7ms			with child process: 2361									
45.7:	2787.6kbps	avg	(2782.8[inst], 2790.2[mov,avg])	cwnd	22	rtt	87.7ms			Handling client 10.10.0.1									
46.1:	2787.5kbps	avg	(2781.6[inst], 2789.3[mov,avg])	cwnd	12	rtt	43.9ms			with child process: 2373									

همانطور که مشاهده می شود، مقدار Goodput در این ارتباط حدود 2787Kbps به دست آمده است که بسیار نزدیک به مقدار تئوری (2.86 Mbps) است. دلیل آن هم این است که مقدار packet loss در آزمایش انجام شده بسیار کم است و حداکثر بسته ها ارسال می شوند.