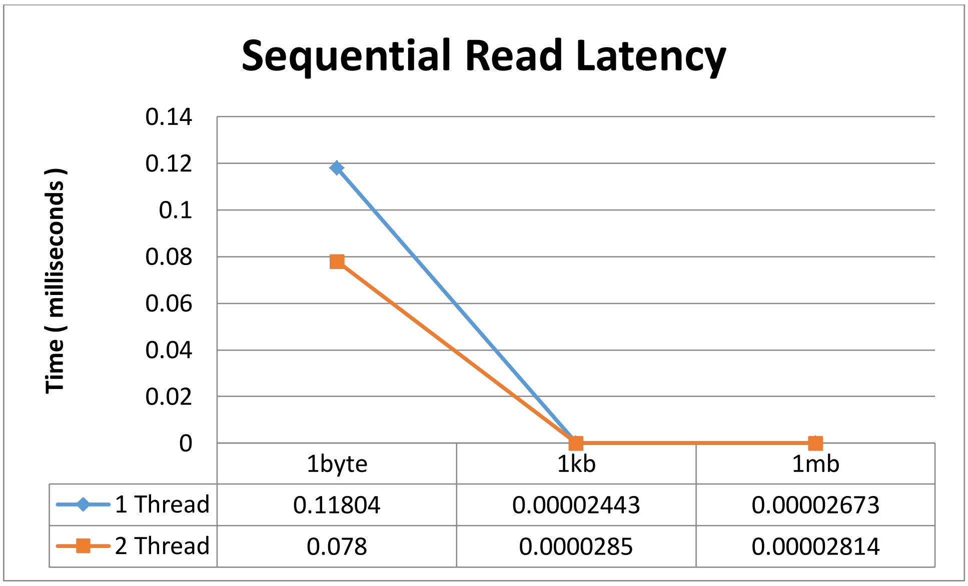
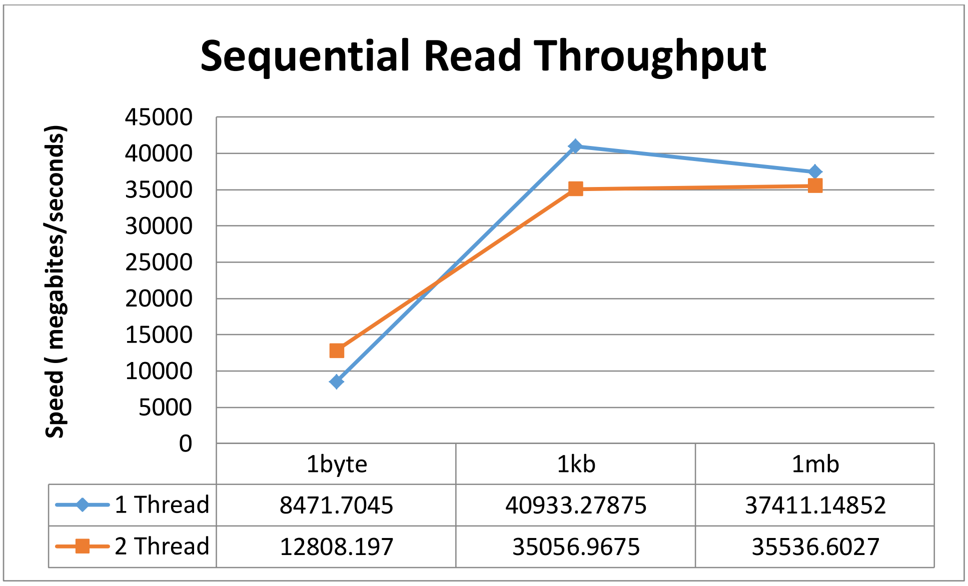
I. Disk Benchmarking:

Following parameters are used for the evaluation:

1. Total size of data : 100 MB
2. Amazon T2.Micro instance

1. Sequential Read operation :

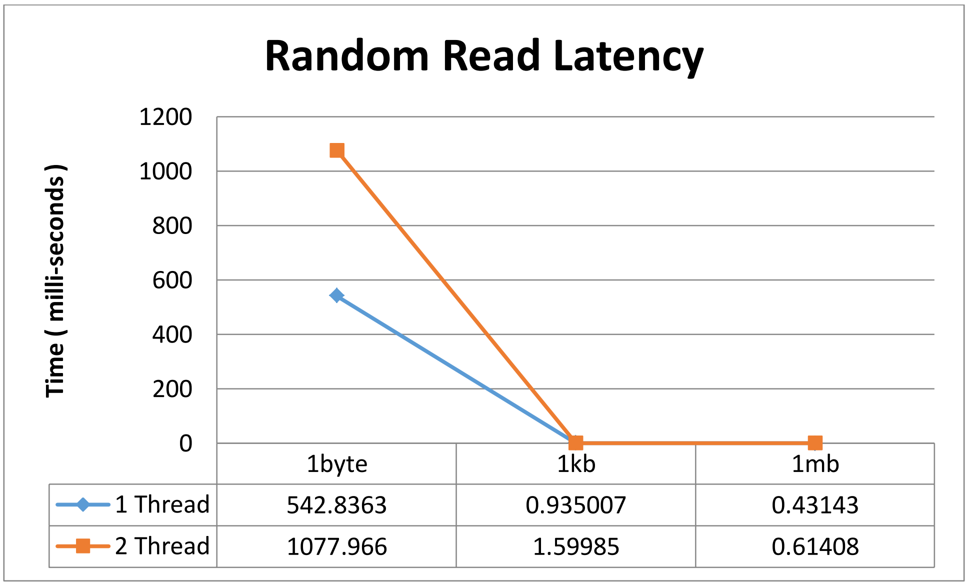


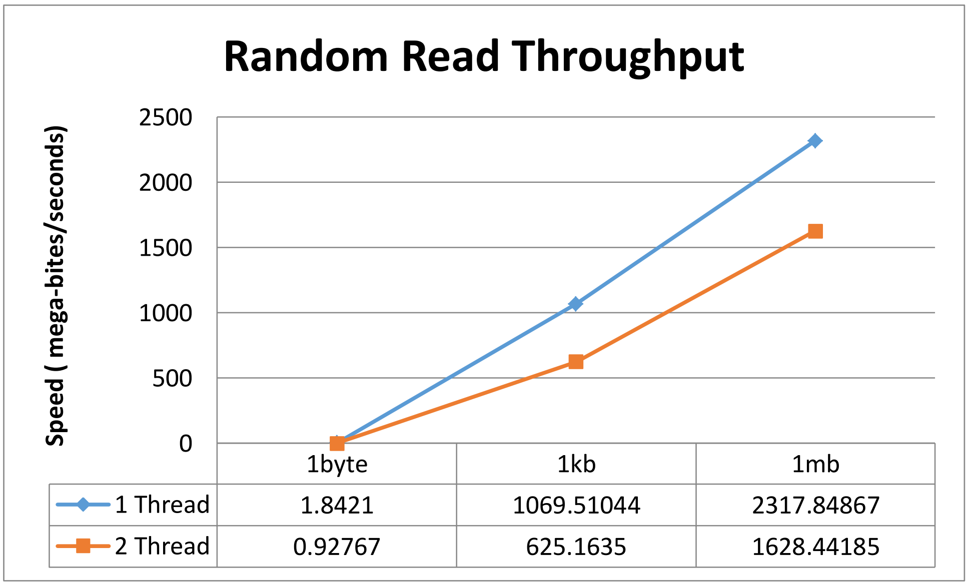


Analysis :

Above graph shows, there is increase in transfer rate of data as number of block-size increases from 1Byte to 1MByte.

2. Random Read Operation:



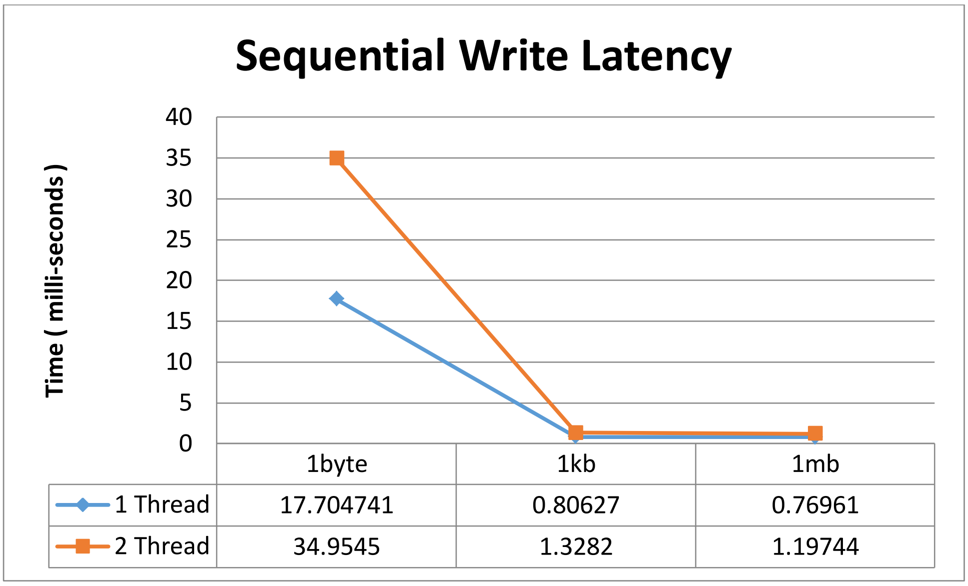


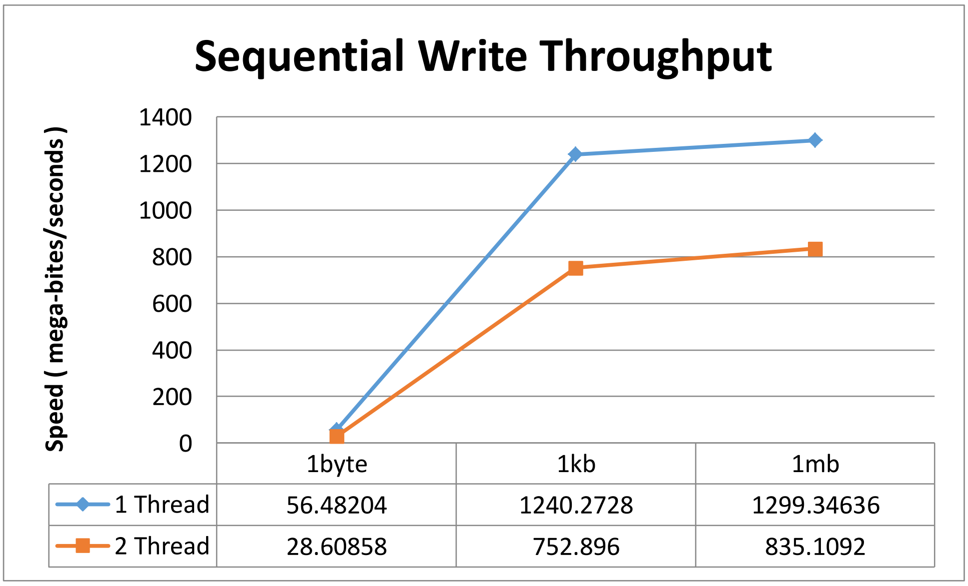
Analysis:

Random read operations gives very bad performance as compared sequential read operation. Following table compares throughput of sequential and random read operation for 1-Thread.

Block Size	Sequential Read	Random Read
1 Byte	8471.7	1.84
1 KByte	40933.27	1069.51
1 Mbyte	37411.14	2317.85

3. equential Write Operation:





Analysis:

There is drastic increase in transfer rate when block size of data increases from 1Byte to 1Kbyte. There is slightly increase in performance when block size increases from 1Kbyte to 1MByte.

Theoretical Performance of a disk:

Amazon has given t2.micro instance theoretical value for disk is given as 160Mb/S.

IOZONE Benchmarking system (Extra Credit)

- Compared evaluation of self implemented benchmarking with IOZONE benchmarking.
- Both systems (mine & IOZONE) are evaluated on amazon's t2.micro instance.
- Imerf has been evaluated for packet size 100MBytes.

```
Auto Mode
Command line used: ./iozone -a
Output is in Kbytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 Kbytes.
Processor cache line size set to 32 bytes.
File stride size set to 17 * record size.
                                                      random  random    bkwd   record   stride
      KB  reclen   write rewrite    read    reread    read   write    read  rewrite     read   fwrite frewrite   fread  freread
      64       4 1330167 3363612  1183548  9006179 8182586 2923952 4897948  4564786 10821524  3203069  3541098 6421025  7100397
      64       8 1232453 3057153 15972885 15972885 7100397 3022727 5735102  5389653 12902017  4207076  4988978 7940539 12902017
      64      16 1255511 4274062 12902017 1597288510821524 3958892 4564786  4897948 12902017  2892445  4564786 5389653 12902017
      64      32 1599680 4274062 15972885 1597288512902017 4897948 6421025  5283570 12310336  3958892  5860307 7940539 15972885
      64      64 1562436 3588436 12902017 3048429715972885 5735102 7940539  4564786 12902017  5283570  4564786 7940539 12902017
     128       4 1406136 3560017  8548124 10779307 9129573 3759450 6406138  4934216  9129573  4012317  3982553 3560017  8036304
     128       8 1618028 4759253 14200794 1588107812842051 4104338 8036304  6114306 12842051  2905056  4407601 9129573 14200794
     128      16 1642783 4759253 14200794 1636517312842051 4135958 8036304  5847904 14200794  4557257  4717434 9795896  9795896
     128      32 1802755 4717434 14200794 1172061411470204 4407601 8036304  5603747  9795896  4407601  5545860 7082197 10779307
     128      64 1663139 4759253 15881078 1801235914200794 5545860 7917784  5545860 14200794  3867787  7082197 6406138 10567140
     128     128 1705404 4717434 14200794 1588107814200794 5122535 6727225  4135958  7082197  5122535  5545860 6406138 12842051
     256       4 1479379 3245838 11207494 11091721 9114515 3410808 7735574  4819184  3756894  3197509  3823789 8534922  7120034
     256       8 1740810 4672389 12090911 1416439512228612 4404088 9434868  6398720 10758322  4496299  375689411569783 14164395
     256      16 2152625 3879045 11091721 1416439512228612 4929815 9868433  5569035 17096249  4264168  2325094 7518900 14353744
     256      32 1985448 5217259  8815202 1607260813454450 5117791 8534922  5347168 10651598  3935921  5320671 7735574 12228612
     256      64 2065659 5320671 14953435 1583556915164624 534716810245071  5841722 11091721  4840911  581011212228612 14164395
     256     128 1911233 5455847  4496299 1516462413454450 534716810651598  4907284 11091721  2366082  8271916 7571923 14164395
     256     256 1600674 5242734  9518507 1281227712228612 3935921 8208677  4907284 10651598  5022044  4496299 6719046 12228612
     512       4 1689859 4163357  8528336 11620224 9304292 3710197 8528336  5227492  6931711  3409755  3993047 7871843  9638369
     512       8 1940253 4701087  8665997 1387212212499490 4237291 9814569  6652558 11138071  4660280  4784885 8844453 13522711
     512      16 2350044 4660280 10235583 1424006913109944 4650188 4871723  6652558 10641343  3913012  487172312427157 13438092
     512      32 1999881 5177083 13190469 1414626513438092 562454511620224  6472112 13109944  3905895  2285029 5278892  6551087
     512      64 2297251 5509113 14146265 1503780113872122 568409512146009  6736026 14628067  5019764  543934313438092 15037801
     512     128 2256220 4099771  9107004 1064134313522711 478488511138071  6319739 11620224  4494470  473216510856530 12797441
     512     256 2225819 4237291 10641343 1064134312215097 474261610434519  5624545 10641343  3849877  730919610856530 11943357
     512     512 1163439 5227492 11620224 12797441 9145790 588665011138071  5760329  7513788  4973263  568409511620224 12797441
    1024       4 1615374 3037876 10134284 11645609 8914314 4146499 6787181  5303701  8326715  3791442  4029784 9765601 10454984
    1024       8 2056183 4674510 13102174 1045498411614118 363116810906310  6963241 11773301  4810640  3984917 7420395 13998981
    1024      16 2115949 5175871 11249091 1423090212208350 553613711018226  7160597  8199542  4110780  432173710134284 13998981
    1024      32 2295784 4142499  8610501 1298335312944224 5720477 9485232  6787181  8822754  3999762  514487012639479 14422045
    1024      64 2124322 5690162 10662628 1461839313264026 5277632 8988941  6787181 14230902  4287225  5065980 7577494 14668318
    1024     128 1874871 4531485 10039528 1364323212639479 609383111614118  7020149 15080341  5593820  4270175 7883484 12071103
    1024     256 2011877 4178773  8262639 1055778511614118 4832290 6280976  5991815 11903823  4876180  4805258 8895850 12313351
    1024     512 2216407 3458646 11018226 1263947912348754 5169641 7160597  5303701 11278631  3804877  5593820 9220512 11903823
    1024    1024 1896395 5444898 13142265 1279003712639479 572047712037272  5169641  9142007  5623115  4396951 8262639 11489839
```

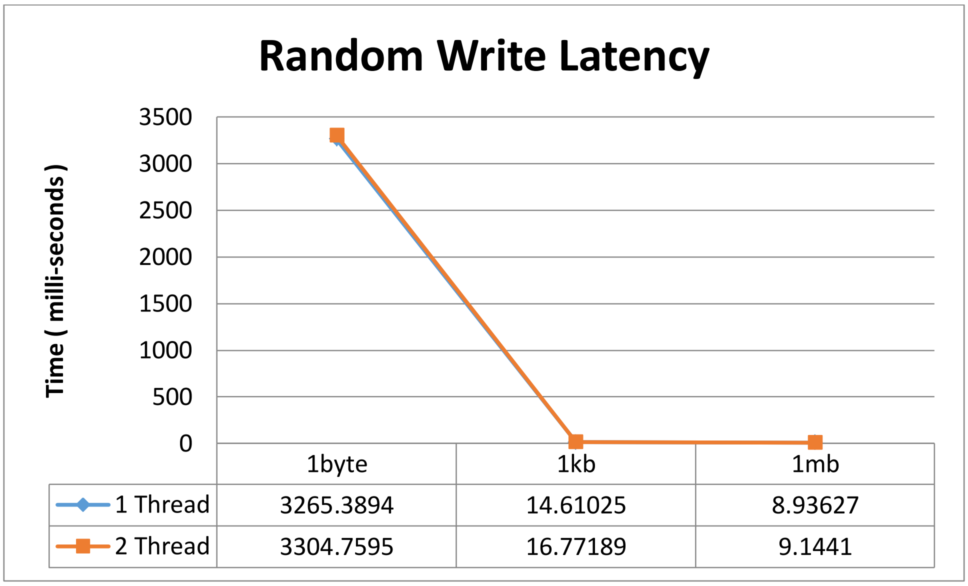
Following are the results for 1024KB :

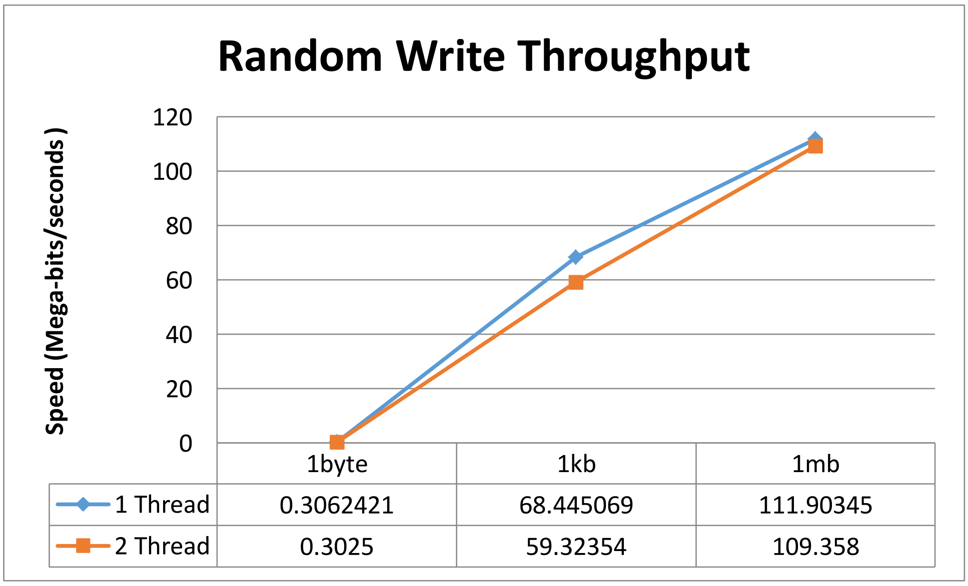
Operations	Throughput in MB/S
Sequential Read	9402.175
Sequential Write	2403.712
Random Read	9142.007
Random Write	3908.759

- **Comparing this values with my system values.**

Operations	My System Throughput	IOZONE Throughput
Sequential Read	40933.27	10134284
Sequential Write	1240.2728	1615374
Random Read	1069.51	8914314
Random Write	68.44	4146499

4. Random Write Operation:





Analysis:

There is huge drop in performance when compared to sequential write operations. Following table compares throughput of sequential and random write operation for 1-Thread.

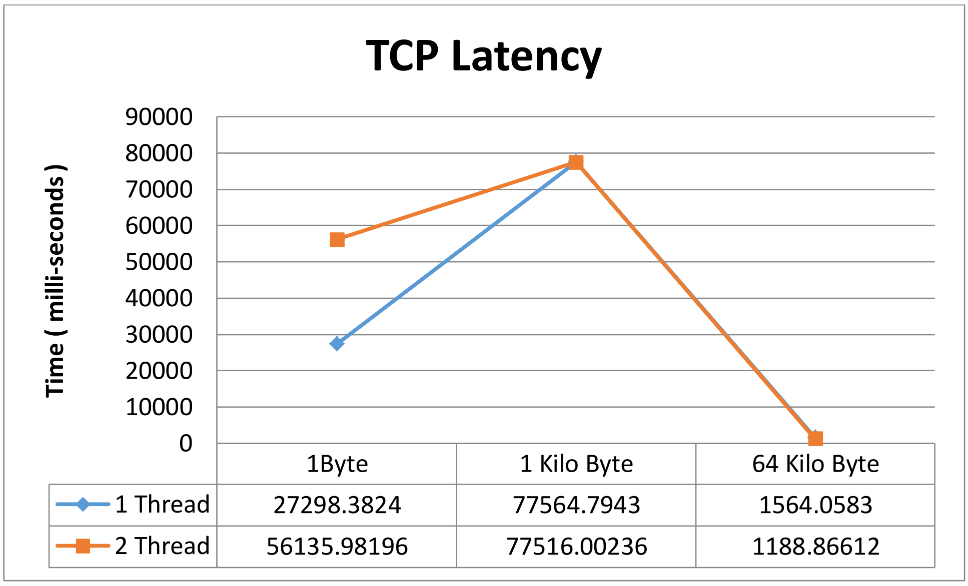
Block Size	Sequential Write	Random Write
1 Byte	56.48	0.30
1 KByte	1240.27	68.44
1 Mbyte	1299.34	111.90

III. Network Benchmarking

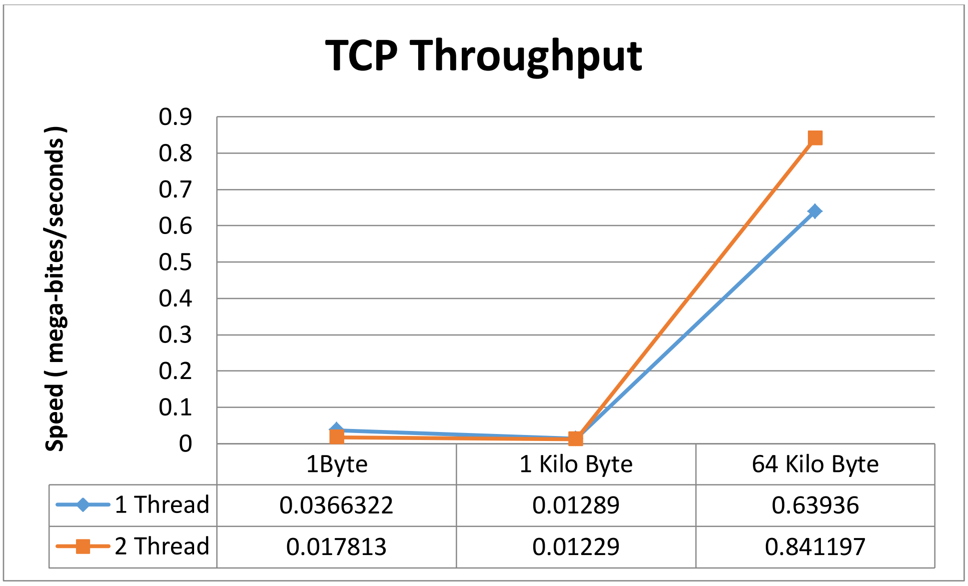
Following parameters are used for the evaluation:

1. Total size of data : 64000 KBytes
2. Amazon T2.Micro instance

1. TCP Operation:



	1Byte	1 Kilo Byte	64 Kilo Byte
1 Thread	27298.3824	77564.7943	1564.0583
2 Thread	56135.98196	77516.00236	1188.86612

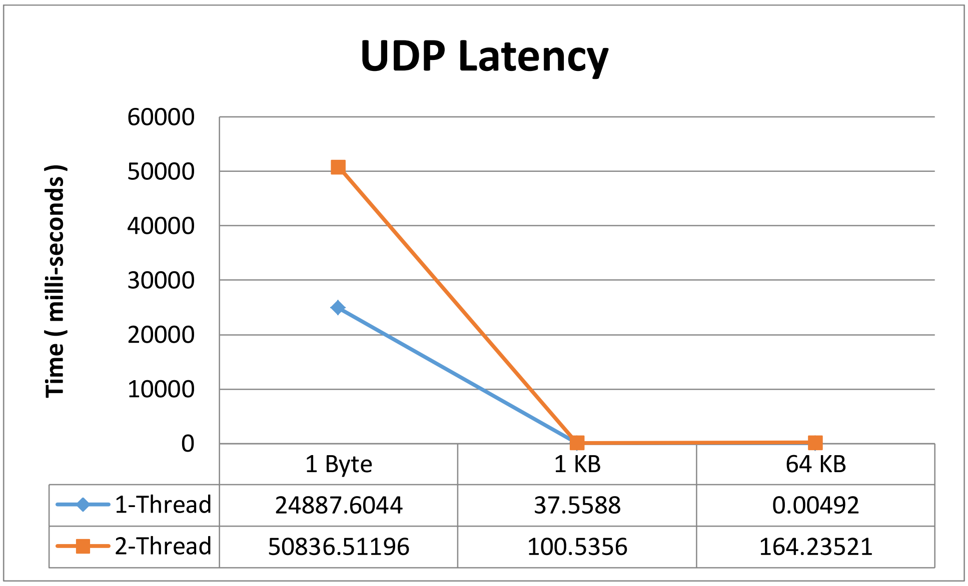


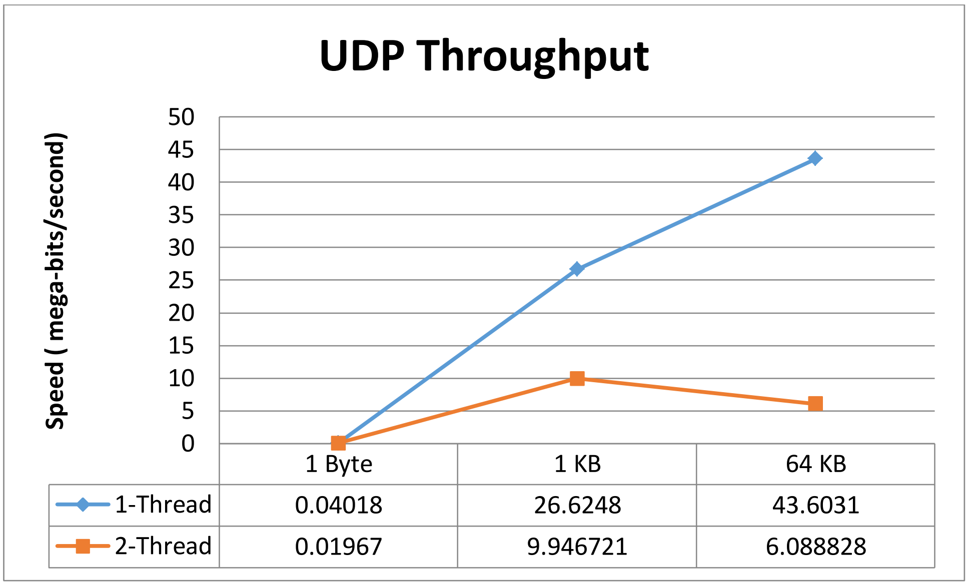
	1Byte	1 Kilo Byte	64 Kilo Byte
1 Thread	0.0366322	0.01289	0.63936
2 Thread	0.017813	0.01229	0.841197

Anaysis:

Throughput of TCP increases drastically when size of packet is increases from 1KByte to 64KByte There is slightly increase in performance when uses multithreading .

2. UDP Operation:





Analysis:

There is increase in performance when the data packets send over network using UDP protocols. Following table compares throughput of UDP and TCP performed on 1-Thread.

Block Size	Sequential Write	Random Write
1 Byte	0.036	0.04
1 KByte	0.012	26.62
1 Mbyte	0.639	43.60

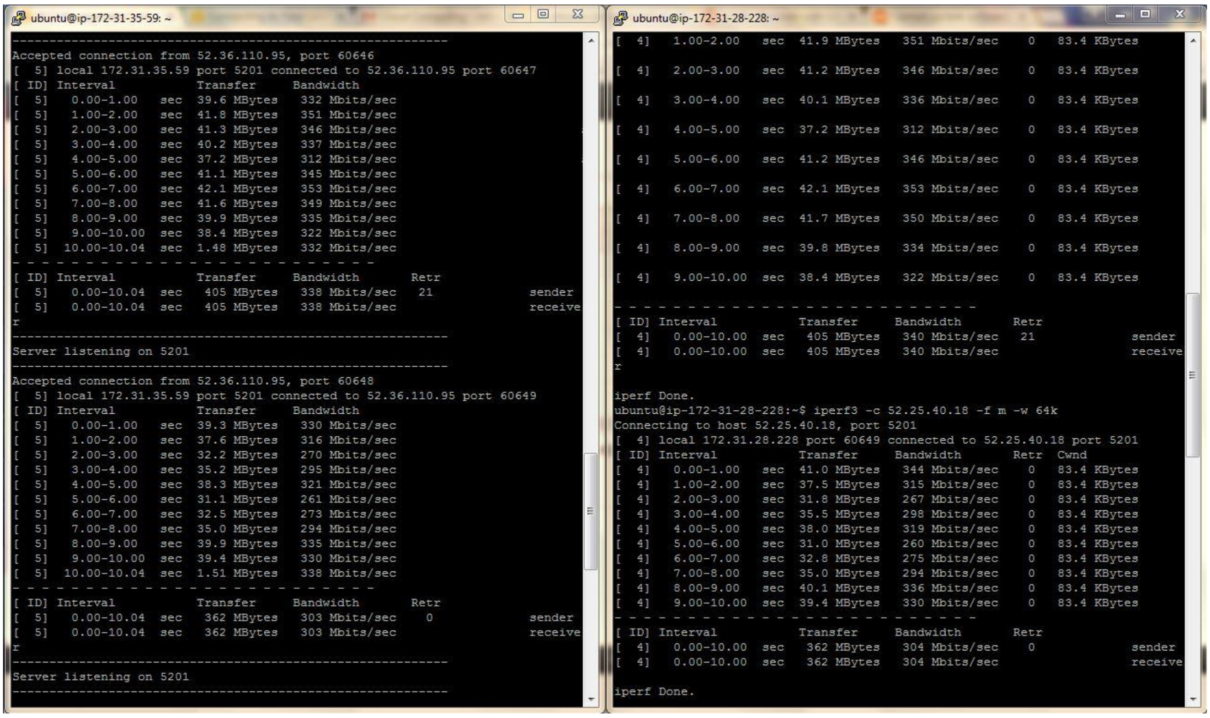
Theoretical Performance of a Network:

- Amazon has given t2.micro instance theoretical value for Network's Bandwidth is given as 2.7MB/S.

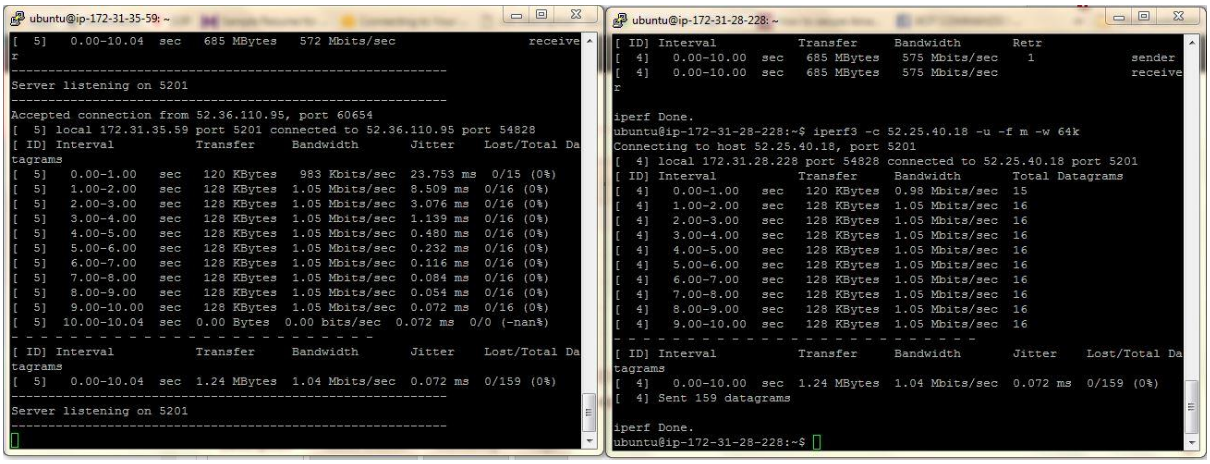
Extra Credit for Network Benchmarking:

- **Iperf Benchmarking system**
    - Compared evaluation of self implemented benchmarking with Iperf benchmarking.
    - Both systems (mine & Iperf) are evaluated on amazon's t2.micro instance.
    - Imerf has been evaluated for packet size 64BK.

Iperf TCP :



Iperf UDP:



Comparing this values with my system values, efficiency for my system is calculated and found to be high as compared to the Iperf performance.

- Instruction to TCP Iperf:
  1. Install Iperf benchmark in local :

     Sudo apt-get install iperf3

  2. Run TCP server
     Iperf3 –s

  3. Run TCP client :
     Iperf3 –c @”public_ip”–f m –w 64k

- Instruction to UDP Iperf:
  1. Install Iperf benchmark in local :

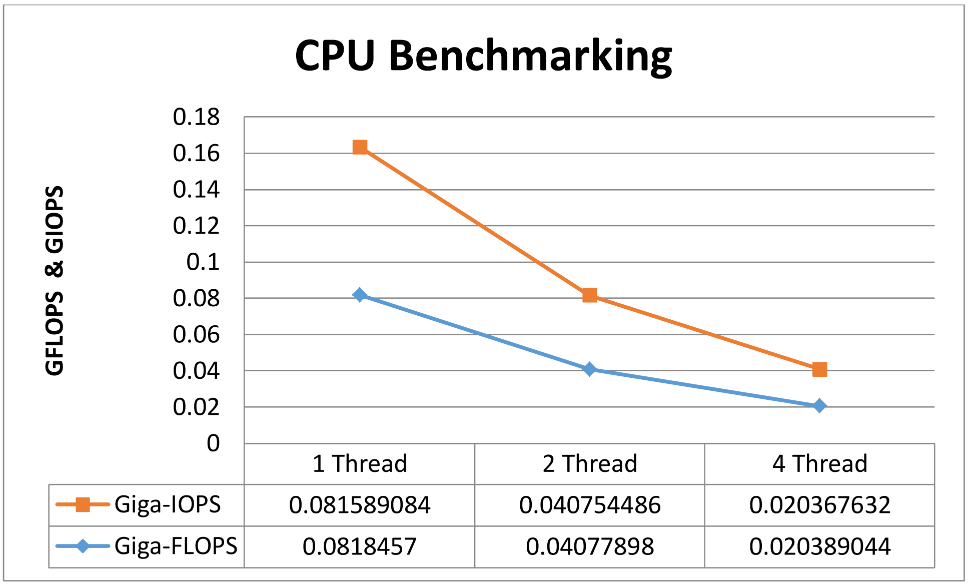
     Sudo apt-get install iperf3

  2. Run TCP server
     Iperf3 –s

  3. Run TCP client :
     Iperf3 –c @”public_ip”–f m –w 64k

- For UDP:
  1. For running a Server :
     Iperf3 –s
  2. Run UDP client:
     Iperf3 –c @”public_ip” –u –f m –w 64k .

III. CPU Benchmarking:



	1 Thread	2 Thread	4 Thread
Giga-IOPS	0.081589084	0.040754486	0.020367632
Giga-FLOPS	0.0818457	0.04077898	0.020389044

X-axis : GFLOPS and GIOPS
Y-axis : Number of threads

- Above Table shows CPU speed in terms of GIGA FLOPS and GIGA IOPS i.e. Giga Floating Point Operation per Second and Giga Integer Operations per second respectively.

- This benchmark is performed in three different threads (1,2 & 4).

- As more threads put more overhead of thread maintenance, concurrency and switching we can conclude that, the optimal number of concurrency for best performance is achieved using 4 threads.

- **Theoretical Peak Performance** = number of cores* clock cycle * FLOPs/cycle
  = 2*1.7*4
  = 13.6 GFLOPS

- **Efficiency** = (FLOPS for 1 thread /Theoretical Peak Performance)*100
  = (0.081589/13.6)* 100
  = 0.5 %