CS 553
Cloud Computing
Programming Assignment 1
Performance Document
Submitted By:
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Note:

- CPU, Memory, Disk and Network benchmarks are performed on Chameleon Open Stack KVM cloud m1.medium instance.

Flavor Details: m1.medium

ID	3
VCPUs	2
RAM	4GB
Size	40GB

- GPU benchmarking is performed on Chameleon Bare Metal GPU M40 instance

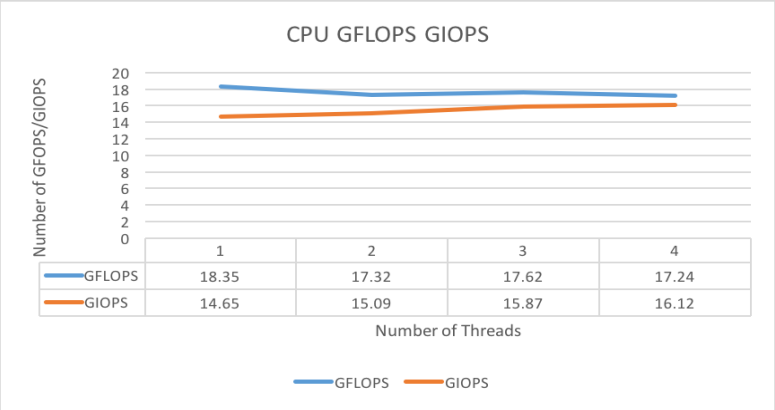
Flavor Details: baremetal

ID	baremetal
VCPUs	4
RAM	31.3GB
Size	100GB

- Contributions:
  - CPU, GPU and Network benchmarks are completed by Aditya Jadhav and Disk and Memory by Sumedha Gupta.

CPU Benchmarking

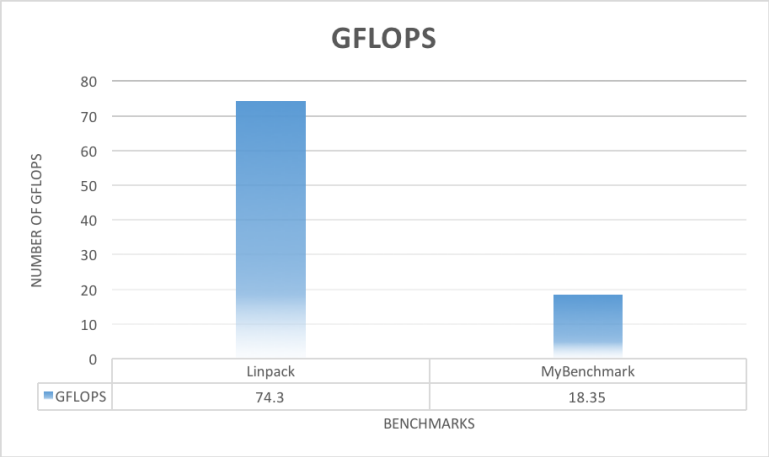
- Strong Scaling is used to do all the experiments.
- In this section, the GFLOPS and GIOPS are calculated for different number of threads as shown below in the graphical representation:



- We have run the Linpack benchmark and various reading have been taken. For the comparison, average reading is considered.

```
cc@pa1-sg:/tmp/l_mklb_p_2018.0.006/benchmarks_2018/linux/mkl/benchmarks/linpack
Current date/time: Sat Oct  7 16:37:03 2017

CPU frequency:    3.059 GHz
Number of CPUs: 2
Number of cores: 2
Number of threads: 2

Parameters are set to:

Number of tests: 15
Number of equations to solve (problem size) : 1000  2000  5000  10000 15000 18000 20000 22000 25000 26000 27000 30000 35000 40000 45000
Leading dimension of array                  : 1000  2000  5008  10000 15000 18008 20016 22008 25000 26000 27000 30000 35000 40000 45000
Number of trials to run                     : 4     2     2     2     2     2     2     2     2     2     1     1     1     1     1
Data alignment value (in Kbytes)            : 4     4     4     4     4     4     4     4     4     4     1     1     1     1     1

Maximum memory requested that can be used=3202964416, at the size=20000

================ Timing linear equation system solver ================

Size   LDA    Align. Time(s)    GFlops   Residual     Residual(norm) Check
1000   1000   4      0.019      35.7829  9.394430e-13 3.203742e-02   pass
1000   1000   4      0.015      43.3941  9.394430e-13 3.203742e-02   pass
1000   1000   4      0.015      46.0414  9.394430e-13 3.203742e-02   pass
1000   1000   4      0.013      49.9148  9.394430e-13 3.203742e-02   pass
2000   2000   4      0.083      64.2622  4.085732e-12 3.554086e-02   pass
2000   2000   4      0.082      64.9343  4.085732e-12 3.554086e-02   pass
5000   5008   4      1.263      65.9969  2.262585e-11 3.154992e-02   pass
5000   5008   4      1.171      71.2238  2.262585e-11 3.154992e-02   pass
10000  10000  4      9.335      71.4385  9.187981e-11 3.239775e-02   pass
10000  10000  4      9.312      71.6111  9.187981e-11 3.239775e-02   pass
15000  15000  4      29.310     76.7816  2.219450e-10 3.495671e-02   pass
15000  15000  4      29.617     75.9849  2.219450e-10 3.495671e-02   pass
18000  18008  4      52.595     73.9360  2.886628e-10 3.161212e-02   pass
18000  18008  4      52.773     73.6859  2.886628e-10 3.161212e-02   pass
20000  20016  4      71.782     74.3101  3.669736e-10 3.248520e-02   pass
20000  20016  4      71.800     74.2912  3.669736e-10 3.248520e-02   pass

Performance Summary (GFlops)

Size   LDA    Align.  Average  Maximal
1000   1000   4       43.7833  49.9148
2000   2000   4       64.5982  64.9343
5000   5008   4       68.6104  71.2238
10000  10000  4       71.5248  71.6111
15000  15000  4       76.3832  76.7816
18000  18008  4       73.8110  73.9360
20000  20016  4       74.3007  74.3101

Residual checks PASSED

End of tests
```

Below is the graphical representation of the comparison of our benchmark with Linpack:



Performance achieved by our benchmark is 18.35 GFLOPS and by linpack is 74.3 GFLOPS. It is less as linpack uses AVX instructions which provide better performance.
Performance achieved in comparison to linpack is ***24.7%.***

- **Theoretical performance and efficiency achieve compared to the theoretical performance?**

As per the specifications of Chameleon Open Stack KVM cloud m1.medium instance.
To check the specifications, the following command has been used:

$ cat /proc/cpuinfo

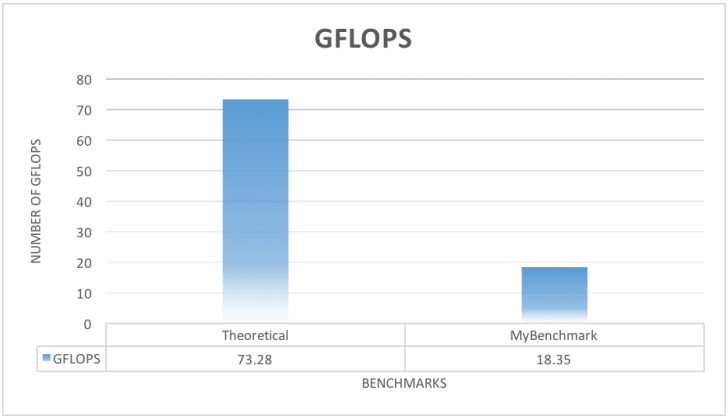
IPC have been checked on the Intel website for Intel Xeon E312 (Sandy Bridge).

GFLOPS = (CPU speed in GHz) x (number of CPU cores) x (CPU instruction per cycle) x (number of CPUs per node)

= (2* 2.29 * 2* 8)

= 73.28

Comparison with our benchmark:

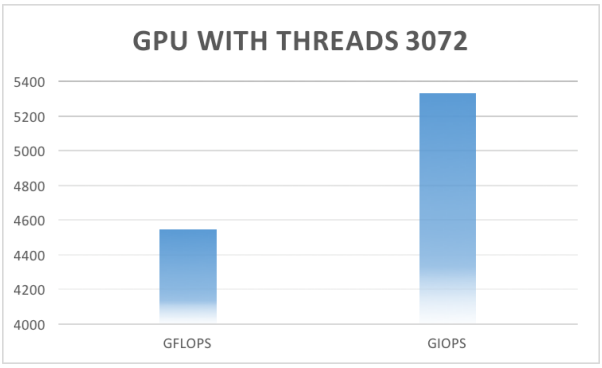


Performance achieved in comparison to theoretical performance is ***25.04%.***

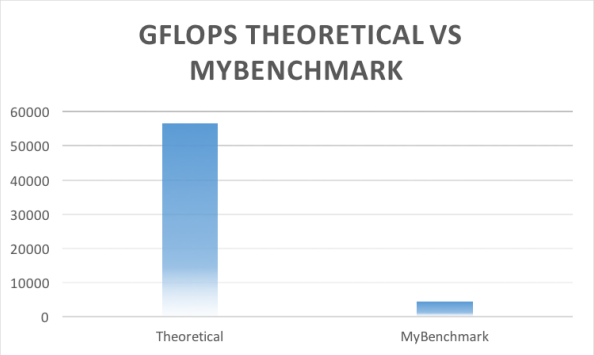
- Linpack and theoretical performance are almost same so we can conclude that their efficiency is same.

GPU Benchmarking

- In this section, the GFLOPS and GIOPS are calculated on GPU M40 and results are shown below in the graphical representation:



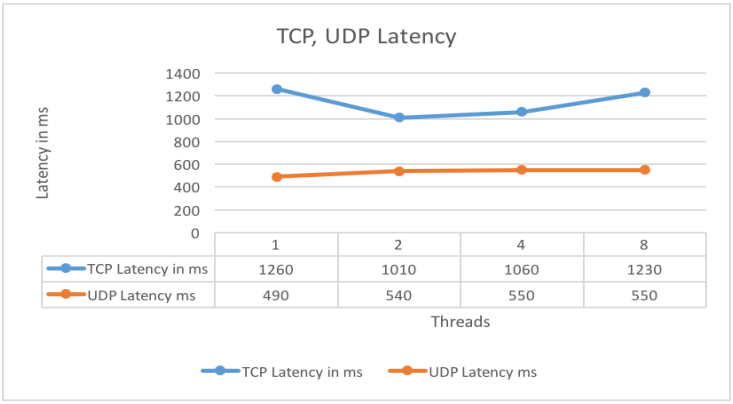
- Theoretical Performance: 2.3 * 3072 * 8 = 56524.8 GFLOPS

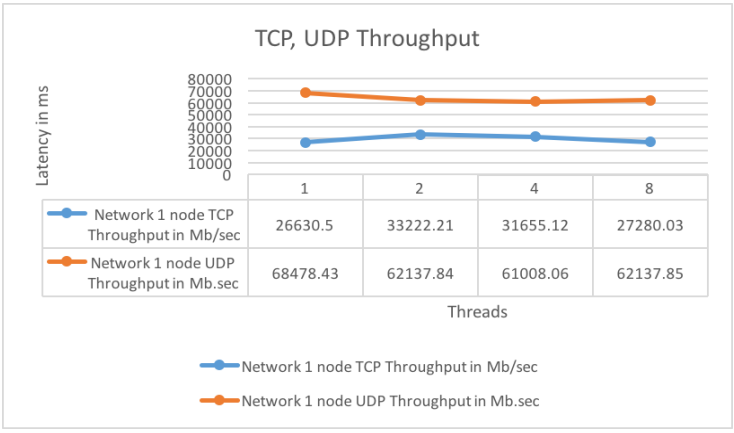


Network Benchmarking

- The data transferred between client and server is done with packet size of 64 KB and 65536 times. So, the total data transferred is 64* 65536*2 = 8GB
- This benchmark is implemented on 1 node as well as 2 nodes.
- Strong Scaling is used to do all the experiments.

Below are the results for 1 node:

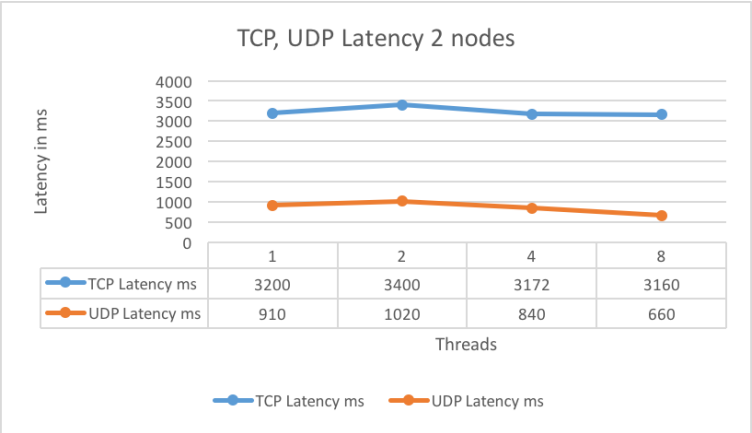


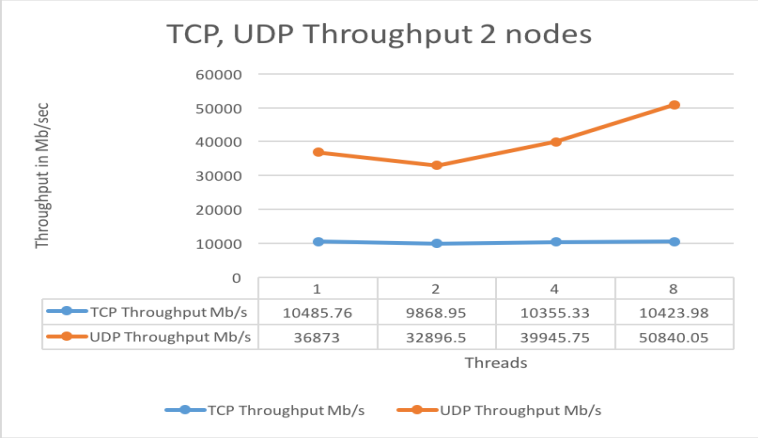


Observations:

- In case of TCP, the fluctuations in the latency are significant as the number of threads increases while the throughput doesn't show much significant change.
- In case of UDP, there is not a significant change in both throughput and latency as the number of thread increases.
- If we compare, TCP and UDP latency and throughput, UDP has much better performance than TCP.

Extra Credit: Below are the results for 2 nodes:





Observations:

- In case of UDP, the fluctuations are significant as the number of threads increases. This may be because of the loss of data packets.
- In case of TCP, there is not a significant change in both throughput and latency as the number of thread increases.
- If we compare, TCP and UDP latency and throughput, UDP has much better performance than TCP.

IPerf benchmark Ouput:

- This benchmark has been tested on the Chameleon medium instance and below are the instrustions to run the benchmark:

  Server:

  Iperf3 -s

  Client TCP:

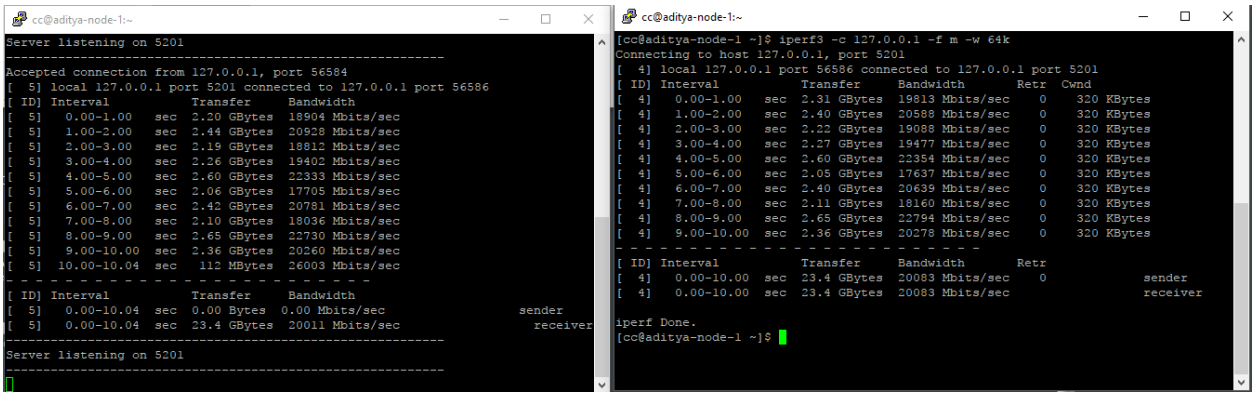
  iperf3 -c <IP_ADDRESS> -w 64k -f Mb

  where, -w -> window size

  -f -> format to report: Kbits, Mbits, KBytes, MBytes

  -c -> server ip

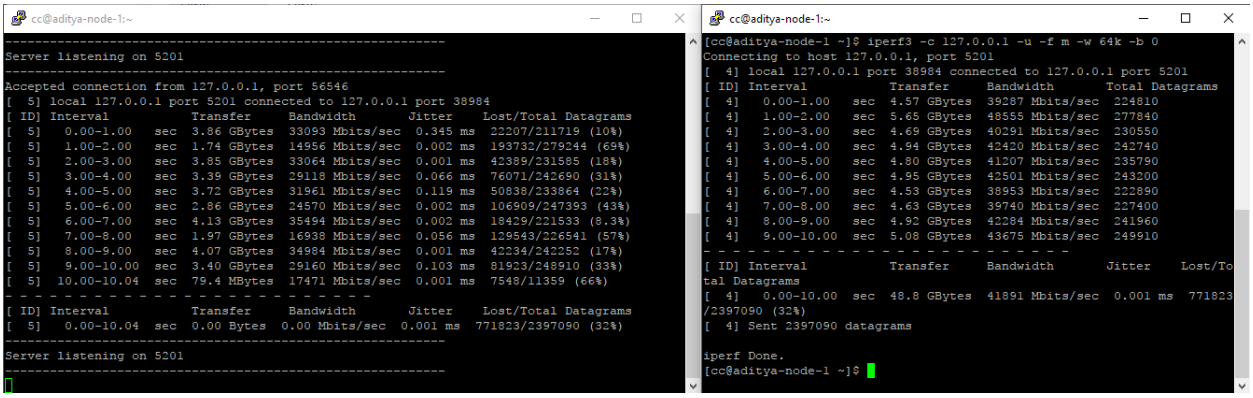
The output for TCP 1 node on IPerf:



Client UDP:

iperf3 -u -c <IP_ADDRESS> -w 64k -f Mb -b
where,-u -> UDP
-w -> window size
-f -> format to report: Kbits, Mbits, KBytes, MBytes
-c -> server ip
-b -> 0, will disable bandwidth limits (particularly useful for UDP tests)

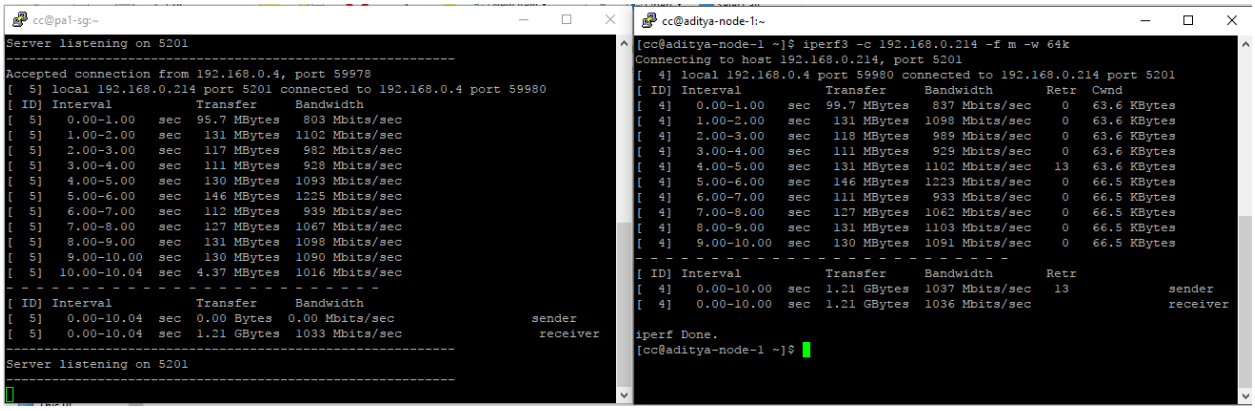
The output for UDP 1 node on IPerf:



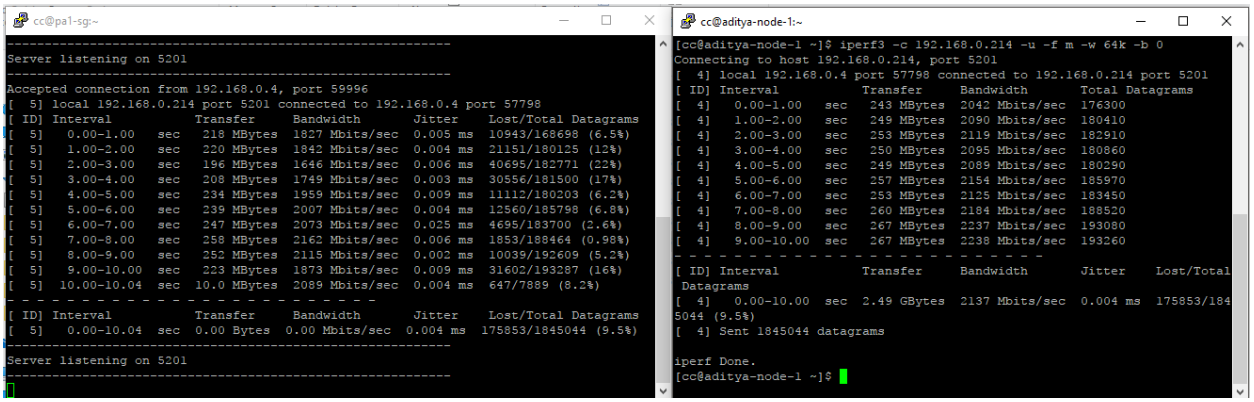
- What efficiency do you achieve compared to the theoretical network performance?

  Theoretical Data Rate is 10000 MB/sec i.e. 10GB/sec and our is 2GB/sec. So, ***20% efficiency***

- Repeat the benchmark across two nodes; what efficiency do you achieve compared to the theoretical network speed?
  Iperf output is approx.
  The output for TCP 2 nodes on IPerf: 1091 MB/sec and is 10% of theoretical performance.

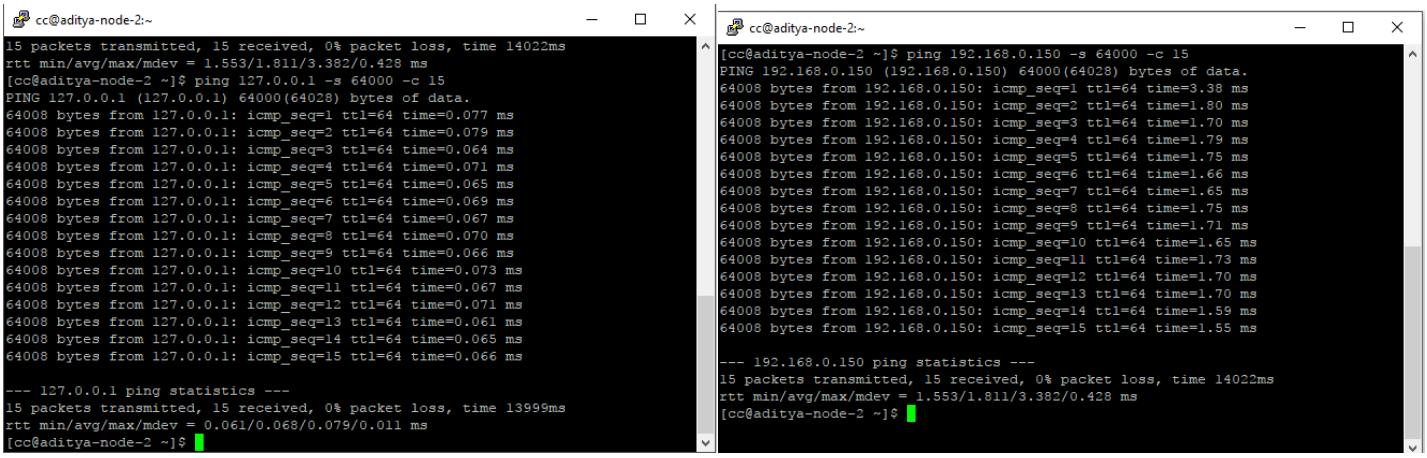


The output for UDP 2 nodes on IPerf:



- For the latency, use the ping utility to measure latency across the loopback, and across the network. How does it compare to the theoretical latency?

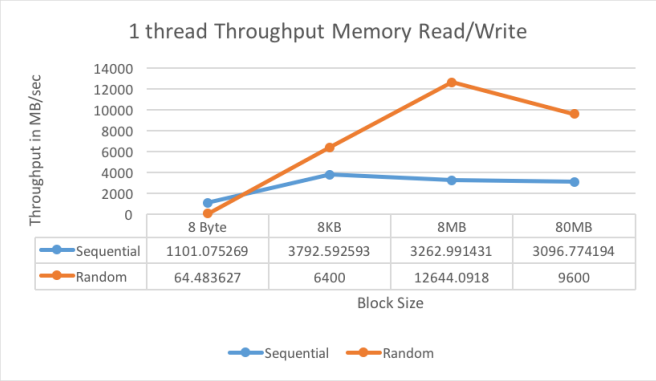
Latency has been measured using ping utility, below is the output on both localhost and network.

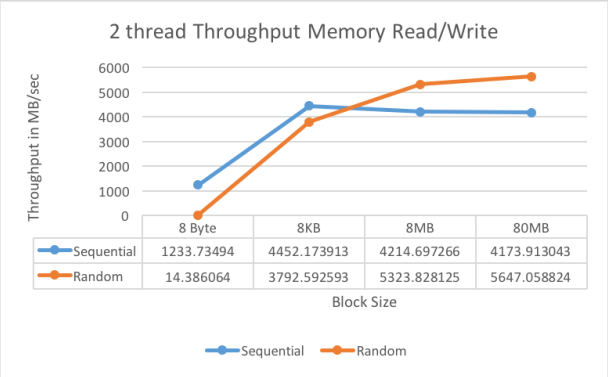


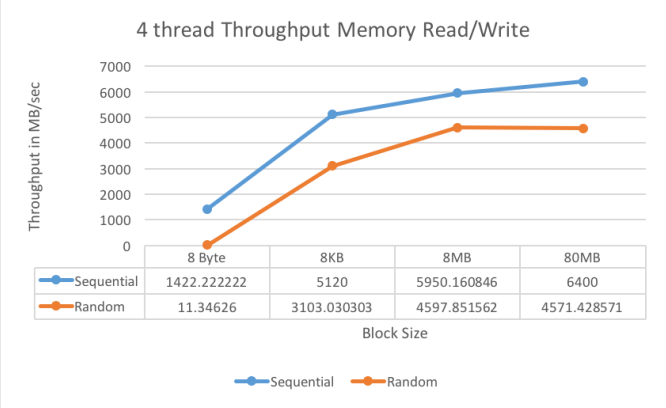
No. of data transferred is 64008 bytes * 15 packets, the average latency is captures as **0.068 ms on localhost and 1.811 ms on network.**

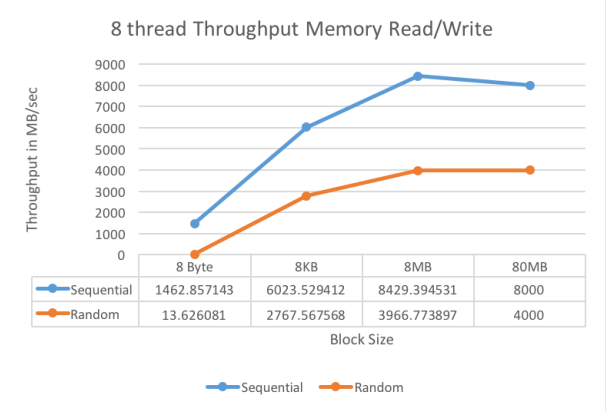
Memory Benchmarking

- Strong Scaling is used to do all the experiments.
- A large piece of memory has been allocated to perform the benchmark. The block sizes of 8B, 8KB, 8MB,80MB with threads varying as 1,2,4 and 8 have been taken.
- Memory read/write sequentially, randomly and write sequentially and randomly functions have been implemented.
- Below are the results for various operations with varying level of concurrency:



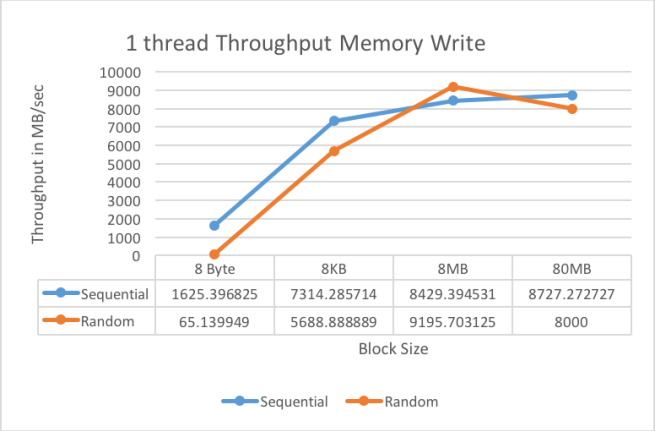


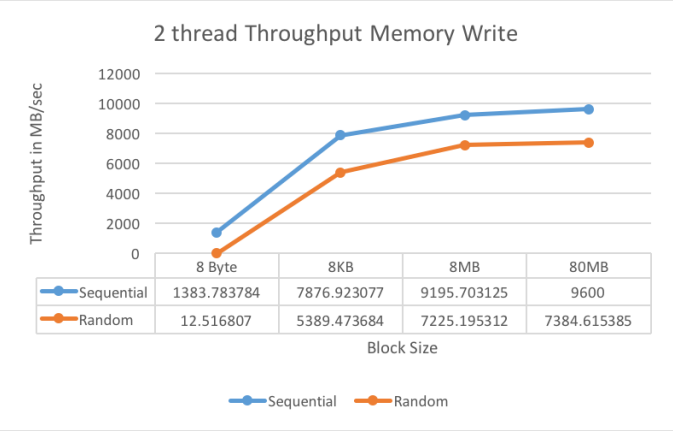


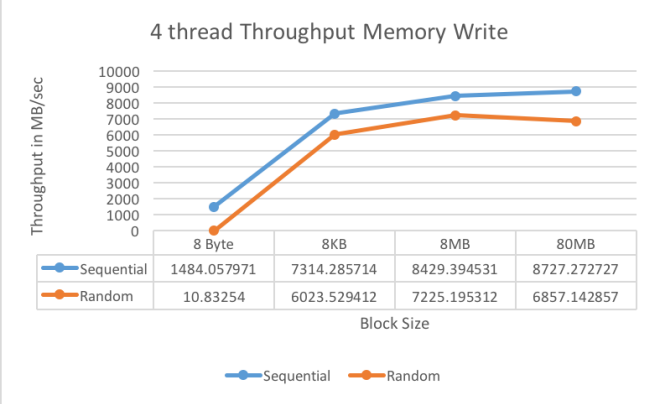


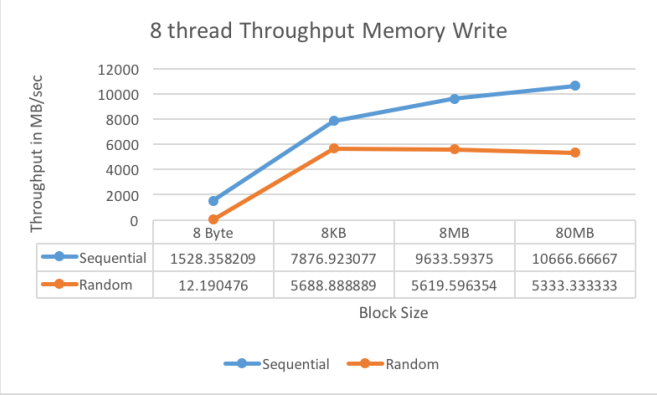
Observations:

- The throughput for sequential read and write operations increases by a significant amount as the number of thread increases and as block size varies.
- The performance of random operation is much less than the sequential except for one thread the performance by random operations is higher than sequential ones.
- Optimal Concurrency:
  - 8threads with 8 MB block size



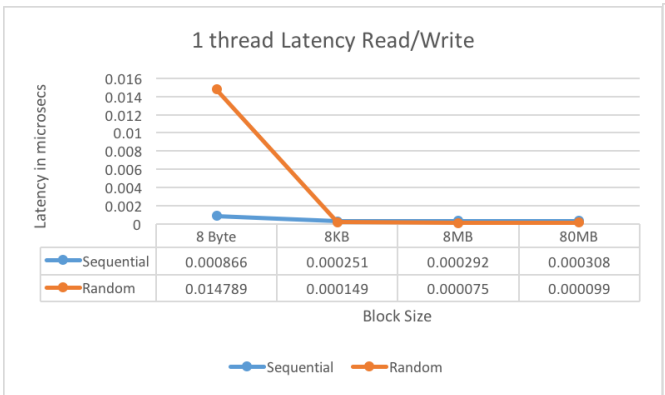


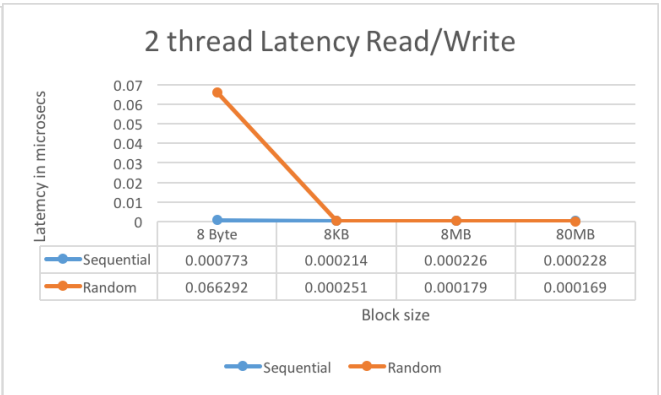


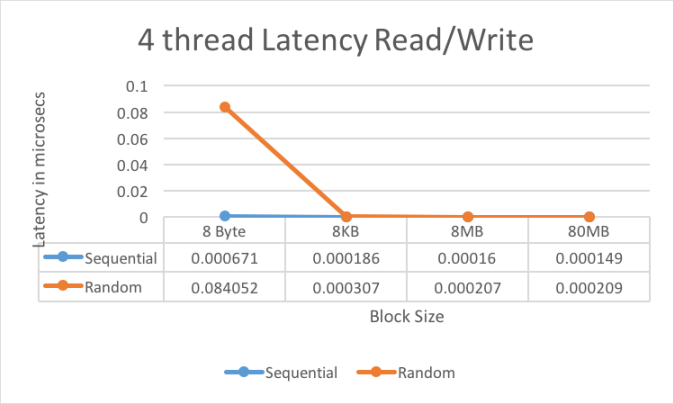


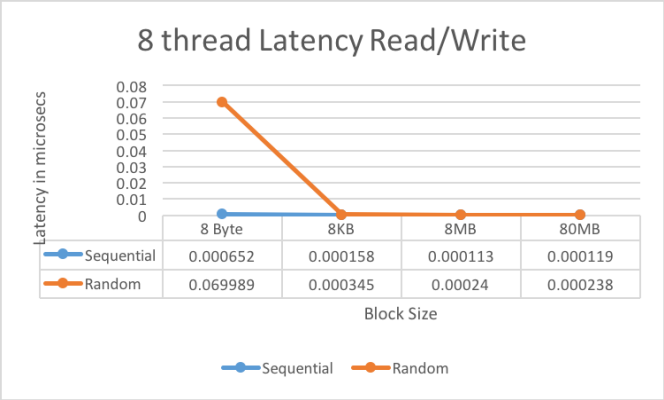
Observations:

- The throughput for sequential memory write operations increases as the number of thread increases and the size of block increases.
- The throughput of random operations is much less than the sequential ones.
- Optimal Concurrency:
  - 8threads with 80 MB block size



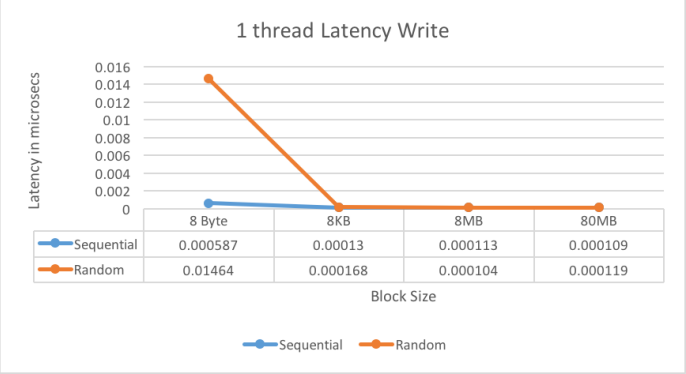


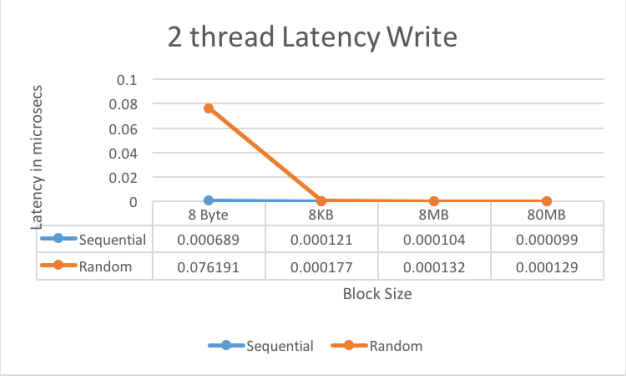


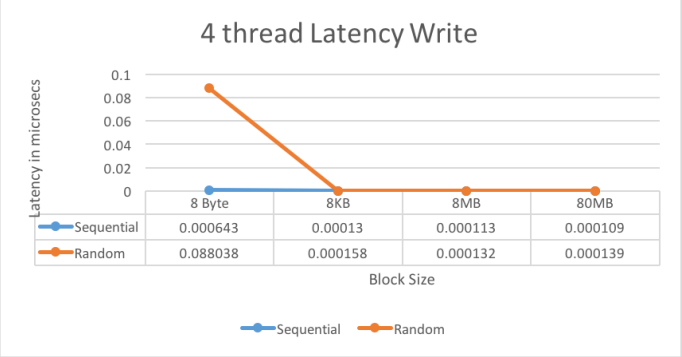


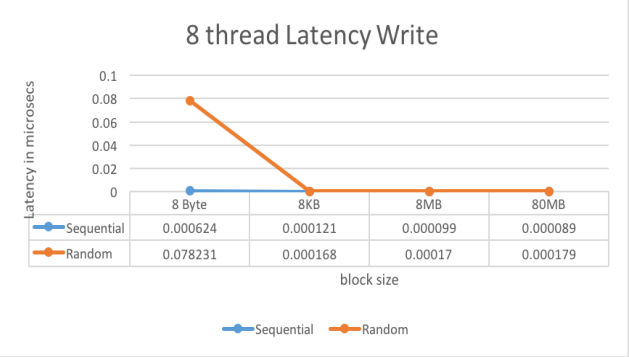
Observations:

- The latency for sequential memory read and write operations doesn't change significantly but decreases by a little amount as the number of thread increases and block size varies.
- The latency for random operations decreases from one thread as the number of thread increases and block size varies.
- Optimal Concurrency:
  - 8threads with 8 MB block size









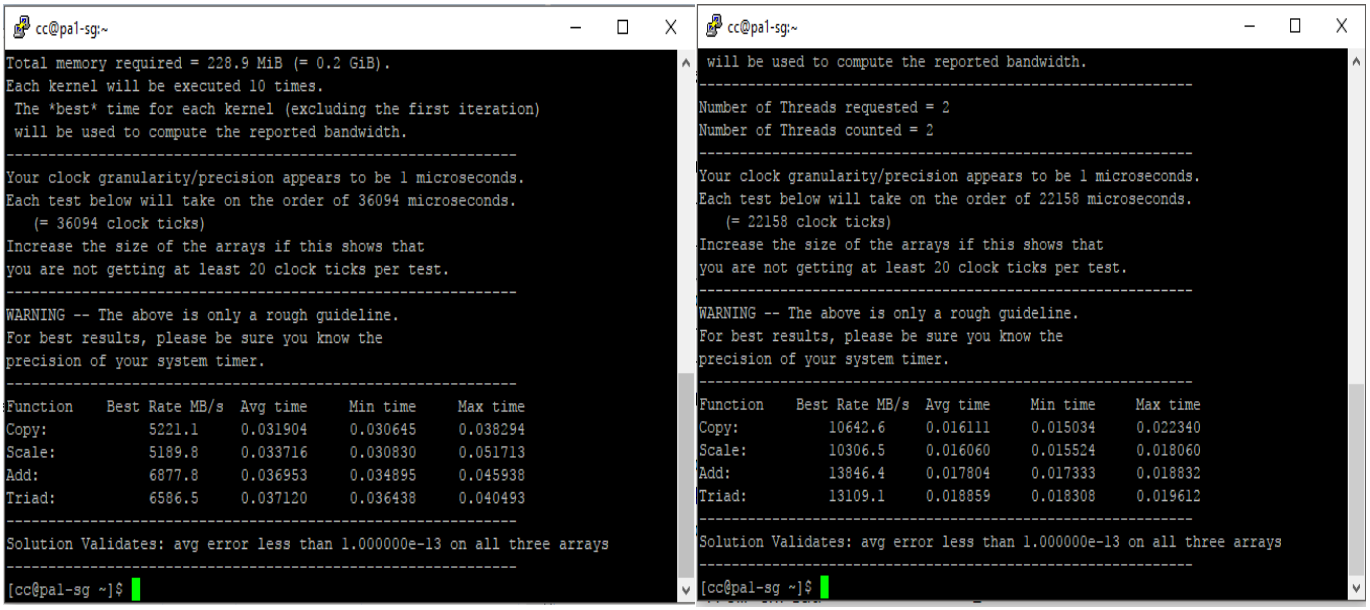
Observations:

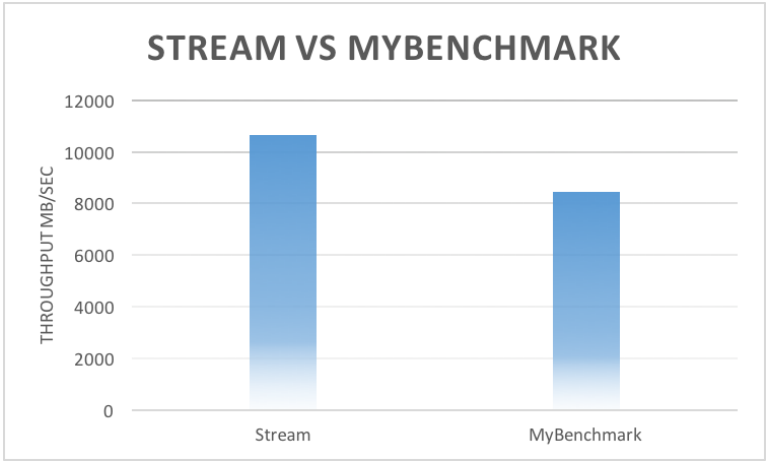
- The latency for sequential memory write operations doesn't change significantly but decreases by a little amount as the number of thread increases and block size varies.
- The latency for random operations decreases from one thread as the number of thread increases and block size varies.
- Optimal Concurrency:
  - 8threads with 80 MB block size

- Theoretical memory bandwidth of your memory
  = cpu clock cyle * type of DDR * 8 IPC
  = 2.29 * 3 * 8
  = 54.96 GB/sec

```
[cc@pa1-sg current]$  sudo dmidecode --type 17 | more
# dmidecode 3.0
Scanning /dev/mem for entry point.
SMBIOS 2.4 present.

Handle 0x1100, DMI type 17, 21 bytes
Memory Device
        Array Handle: 0x1000
        Error Information Handle: 0x0000
        Total Width: 64 bits
        Data Width: 64 bits
        Size: 4096 MB
        Form Factor: DIMM
        Set: None
        Locator: DIMM 0
        Bank Locator: Not Specified
        Type: RAM
        Type Detail: None

[cc@pa1-sg current]$ dmidecode --type 17 | grep -i speed
/dev/mem: Permission denied
[cc@pa1-sg current]$ sudo dmidecode --type 17 | grep -i speed
[cc@pa1-sg current]$ sudo lshw -short -C memory
H/W path        Device     Class          Description
=====================================================
/0/0                       memory         96KiB BIOS
/0/1000                    memory         4GiB System Memory
/0/1000/0                  memory         4GiB DIMM RAM
```

- Stream Benchmark Results:
  - Best performance achieved: The best rate for stream without the openmp flag is 5221.1 MB/sec. We have achieved 8429 MB/sec.
  - With openmp flag: the best rate for stream is 10642 MB/sec and we have achieved 79% as compared to that

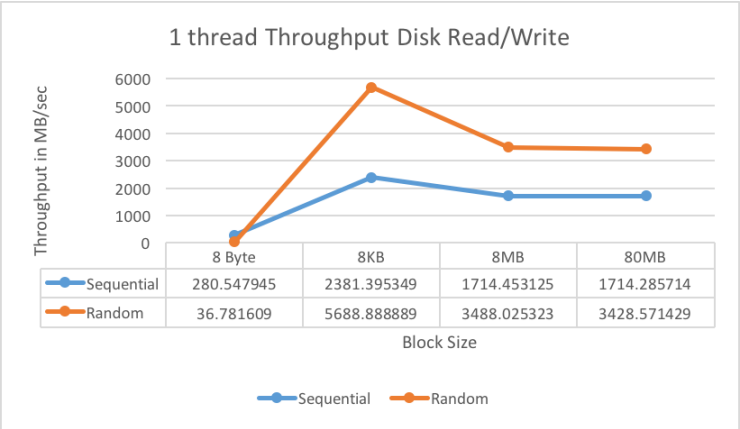


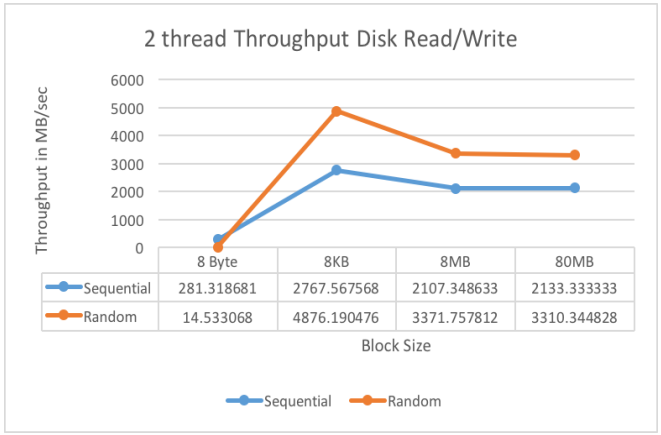


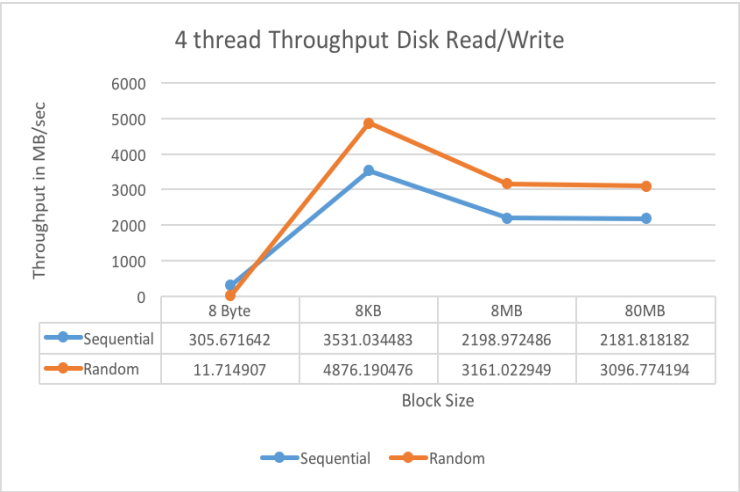
- What efficiency do you achieve compared to the theoretical performance?
  - Our benchmark performance is approx. 8GB/sec while theoretical memory bandwidth of your memory is 54.96 GB/sec.
  - Efficiency Achieved: 14.5 %

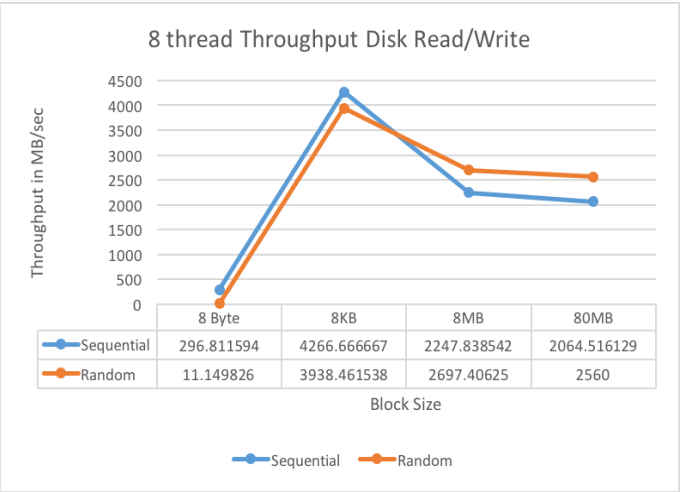
Disk Benchmarking

- Strong Scaling is used to do all the experiments.
- A large file has been allocated to perform the benchmark. The block sizes of 8B, 8KB, 8MB,80MB with threads varying as 1,2,4 and 8 have been taken.
- File read/write sequentially, randomly and write sequentially and randomly functions have been implemented.
- After exploring different APIs to read and write in a disk, fread and fwrite have been identified for the best performance.
- Below are the results for various operations with varying level of concurrency:



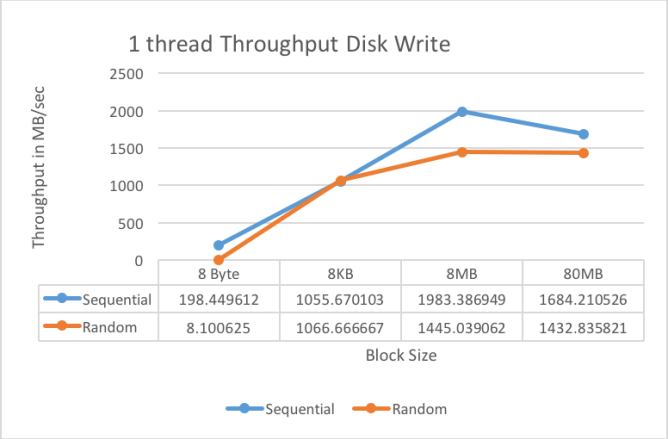




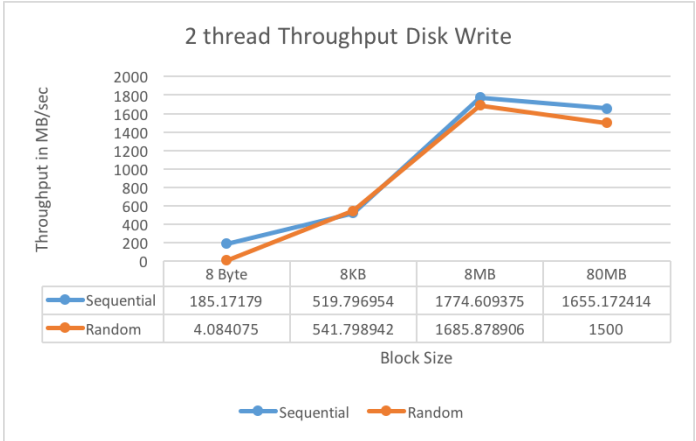


Observations:

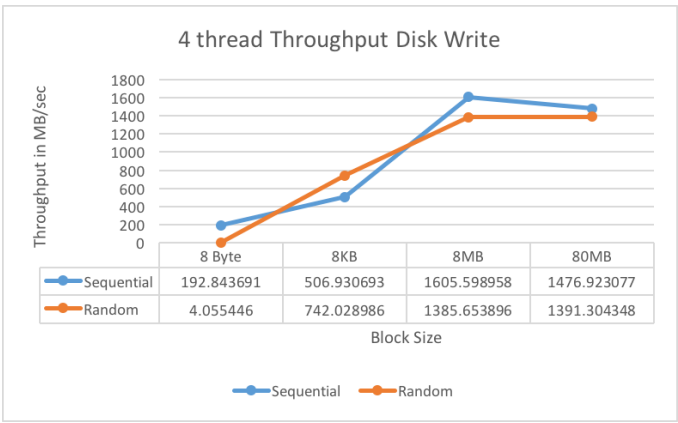
- The throughput for sequential read and write operations increases as the number of thread increases and as block size varies.
- The performance of random operation is high than the sequential except for one thread the performance by random operations is less than sequential ones. Also, the random operation performance is less in case of 8 threads and large block size in comparison to sequential.
- Optimal Concurrency:
    - 8threads with 8 KB block size



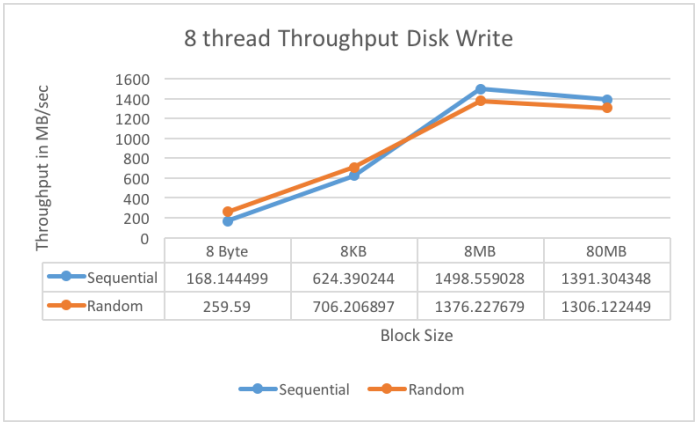
	8 Byte	8KB	8MB	80MB
Sequential	198.449612	1055.670103	1983.386949	1684.210526
Random	8.100625	1066.666667	1445.039062	1432.835821



	8 Byte	8KB	8MB	80MB
Sequential	185.17179	519.796954	1774.609375	1655.172414
Random	4.084075	541.798942	1685.878906	1500



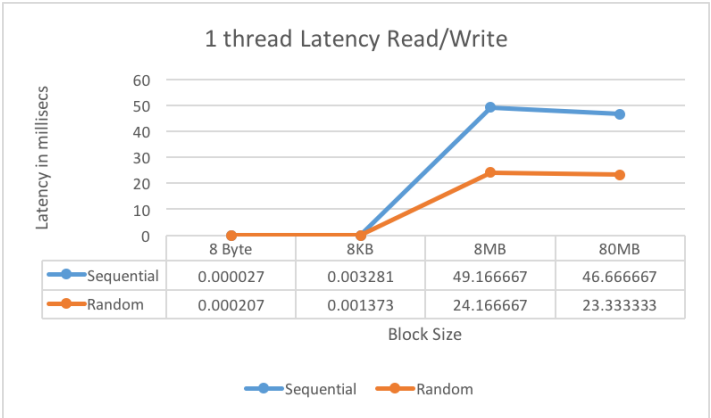
	8 Byte	8KB	8MB	80MB
Sequential	192.843691	506.930693	1605.598958	1476.923077
Random	4.055446	742.028986	1385.653896	1391.304348



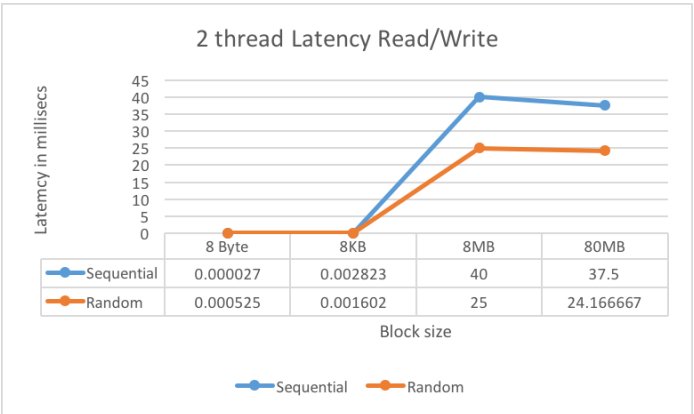
	8 Byte	8KB	8MB	80MB
Sequential	168.144499	624.390244	1498.559028	1391.304348
Random	259.59	706.206897	1376.227679	1306.122449

Observations:

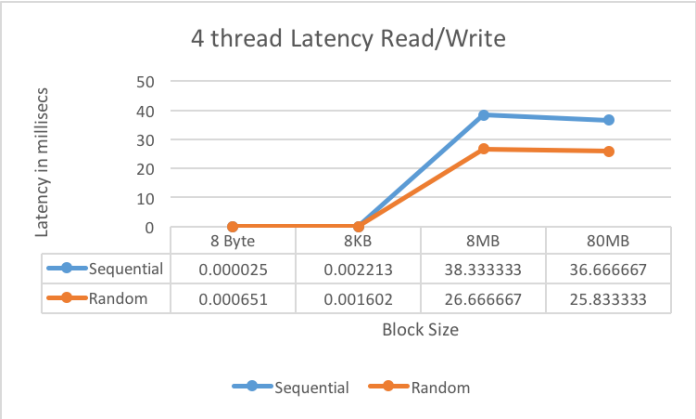
- The throughput for sequential read and write operations increases as the number of thread increases and as block size varies.
- The performance of random operation is a little less than the sequential except for eight thread the performance by random operations is a little high than sequential ones.
- Optimal Concurrency:
  - 1thread with 8 MB block size

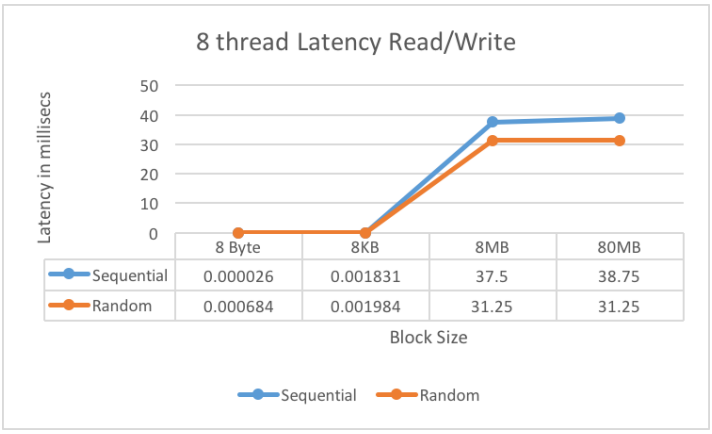


	8 Byte	8KB	8MB	80MB
Sequential	0.000027	0.003281	49.166667	46.666667
Random	0.000207	0.001373	24.166667	23.333333



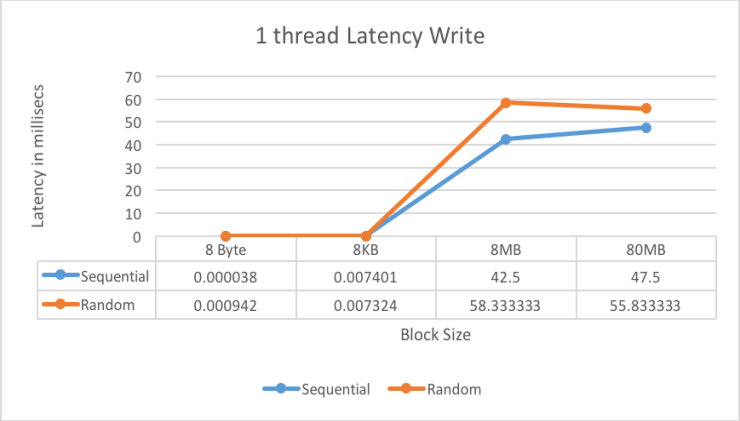
	8 Byte	8KB	8MB	80MB
Sequential	0.000027	0.002823	40	37.5
Random	0.000525	0.001602	25	24.166667

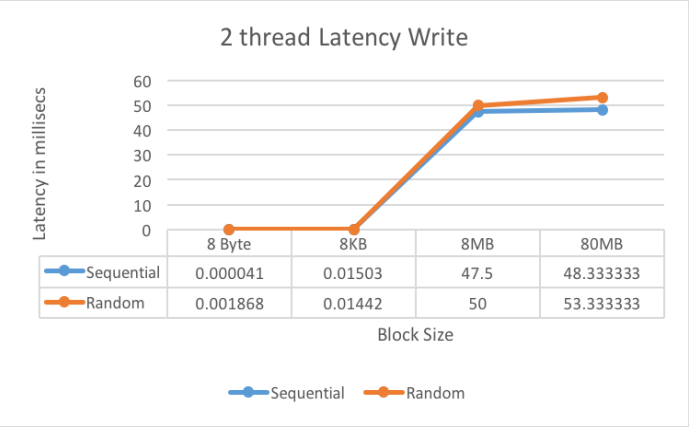


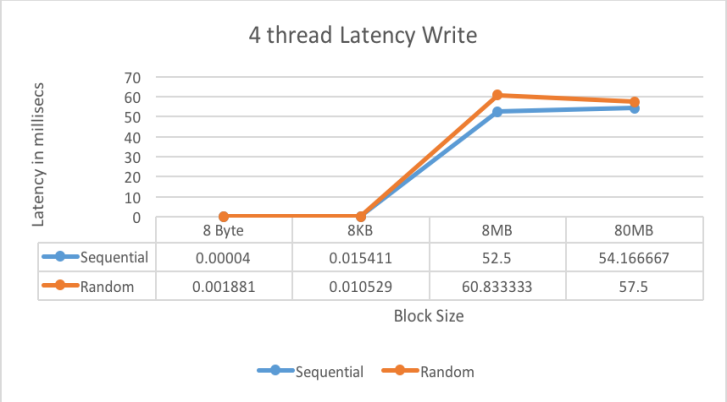


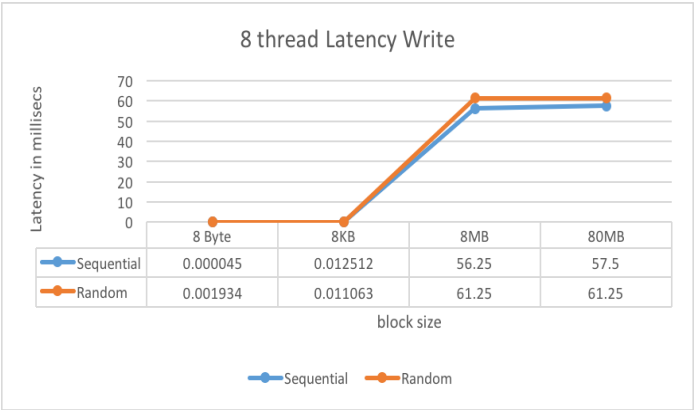
Observations:

- The latency for sequential disk read and write operations change significantly and increases as the number of thread from 2 to 4 and 8 and block size varies.
- The latency for random operations also increases as the number of thread increases from 2 to 4 and 8 and block size varies.
- The latency of random operations is much less than the sequential ones.
- Optimal Concurrency:
  - 8threads with 8B block size









Observations:

- The latency for sequential disk write operations change significantly and increases as the number of thread from 2 to 4 and 8 increases and block size varies.

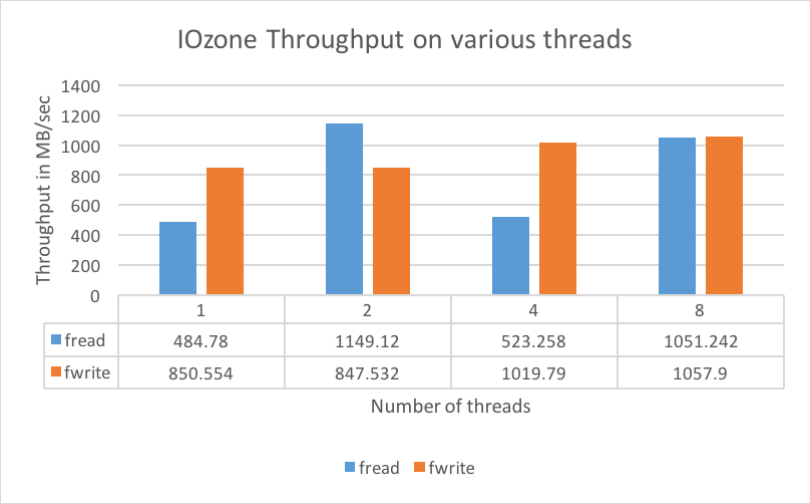
- The latency for random operations also increases as the number of thread increases from 2 to 4 and 8 and block size varies.
- The latency of random operations and sequential ones are almost similar.
- Optimal Concurrency:
    - 8threads with 8B block size

➢ Explain your findings, putting in perspective the hardware you are testing; can you tell if the disk you are evaluating is a spinning hard drive (HDD) or a solid-state memory (SSD) disk?

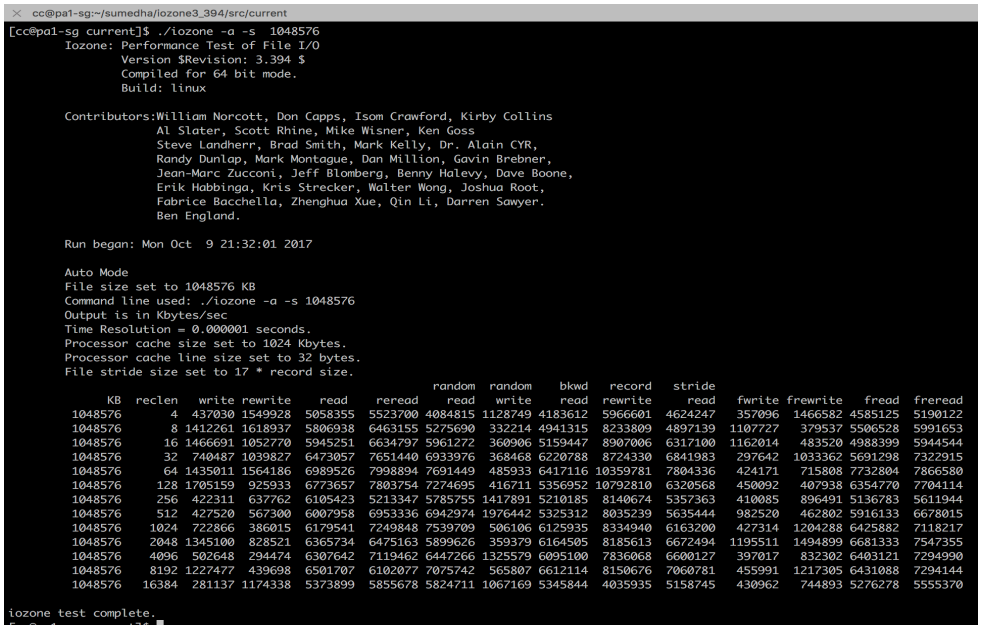
- As per the latency values which depicts very good performance, we have concluded that it's a solid-state memory (SSD) disk

➢ Run the IOZone benchmark

- Best performance achieved for 2 threads for fread: 1149 MB/sec
- Best performance achieved for 3 threads for fwrite: 1019 MB/sec

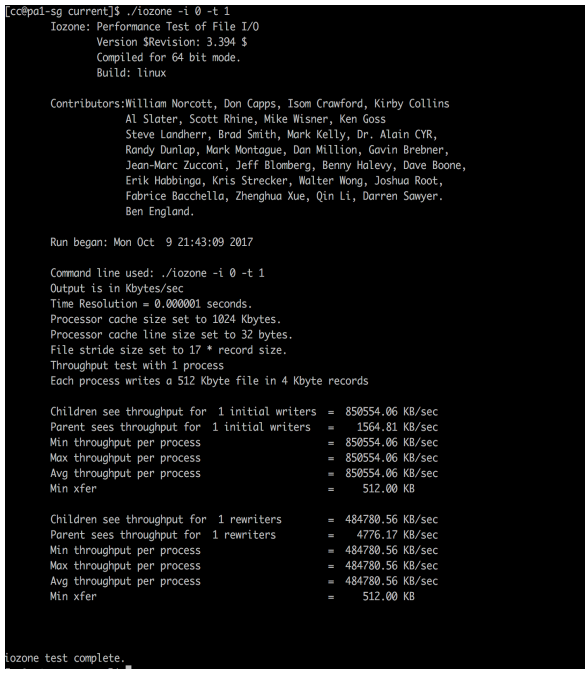


- Comparison with our benchmark: We are getting much better performance than IOzone.
- The IOzone benchmark is done for 1GB file same as our benchmark & got the following output:

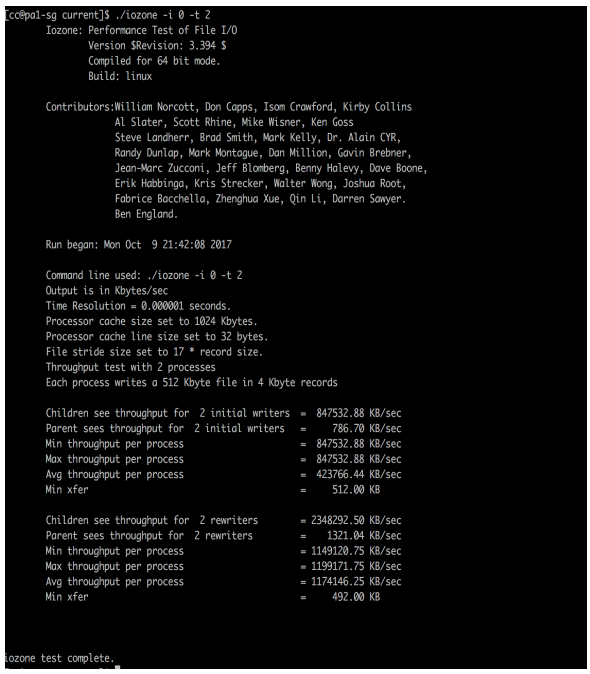


```
cc@pa1-sg:~/sumedha/iozone3_394/src/current
[cc@pa1-sg current]$ ./iozone -a -s  1048576
        Iozone: Performance Test of File I/O
                Version $Revision: 3.394 $
                Compiled for 64 bit mode.
                Build: linux

        Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
                     Al Slater, Scott Rhine, Mike Wisner, Ken Goss
                     Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
                     Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
                     Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
                     Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
                     Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer.
                     Ben England.

        Run began: Mon Oct  9 21:32:01 2017

        Auto Mode
        File size set to 1048576 KB
        Command line used: ./iozone -a -s 1048576
        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
         1048576       4  437030 1549928  5058355  5523700 4084815 1128749 4183612  5966601  4624247   357096  1466582 4585125  5190122
         1048576       8 1412261 1618937  5806938  6463155 5275690  332214 4941315  8233809  4897139  1107727   379537 5506528  5991653
         1048576      16 1466691 1052770  5945251  6634797 5961272  360906 5159447  8907006  6317100  1162014   483520 4988399  5944544
         1048576      32  740487 1039827  6473057  7651440 6933976  368468 6220788  8724330  6841983   297642  1033362 5691298  7322915
         1048576      64 1435011 1564186  6989526  7998894 7691449  485933 6417116 10359781  7804336   424171   715808 7732804  7866580
         1048576     128 1705159  925933  6773657  7803754 7274695  416711 5356952 10792810  6320568   450092   407938 6354770  7704114
         1048576     256  422311  637762  6105423  5213347 5785755 1417891 5210185  8140674  5357363   410085   896491 5136783  5611944
         1048576     512  427520  567300  6007958  6953336 6942974 1976442 5325312  8035239  5635444   982520   462802 5916133  6678015
         1048576    1024  722866  386015  6179541  7249848 7539709  506106 6125935  8334940  6163200   427314  1204288 6425882  7118217
         1048576    2048 1345100  828521  6365734  6475163 5899626  359379 6164505  8185613  6672494  1195511  1494899 6681333  7547355
         1048576    4096  502648  294474  6307642  7119462 6447266 1325579 6095100  7836068  6600127   397017   832302 6403121  7294990
         1048576    8192 1227477  439698  6501707  6102077 7075742  565807 6612114  8150676  7060781   455991  1217305 6431088  7294144
         1048576   16384  281137 1174338  5373899  5855678 5824711 1067169 5345844  4035935  5158745   430962   744893 5276278  5555370

iozone test complete.
```

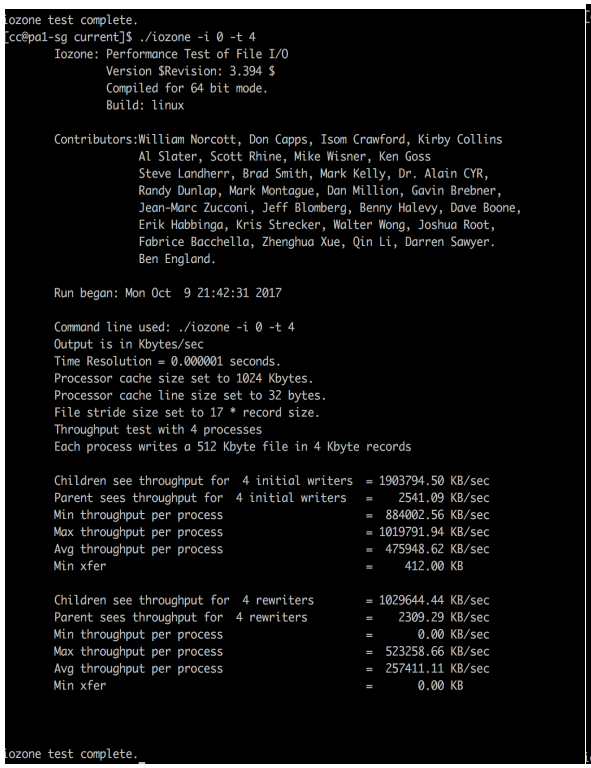
Below is the output for throughput for 1,2,4 8 threads separately:



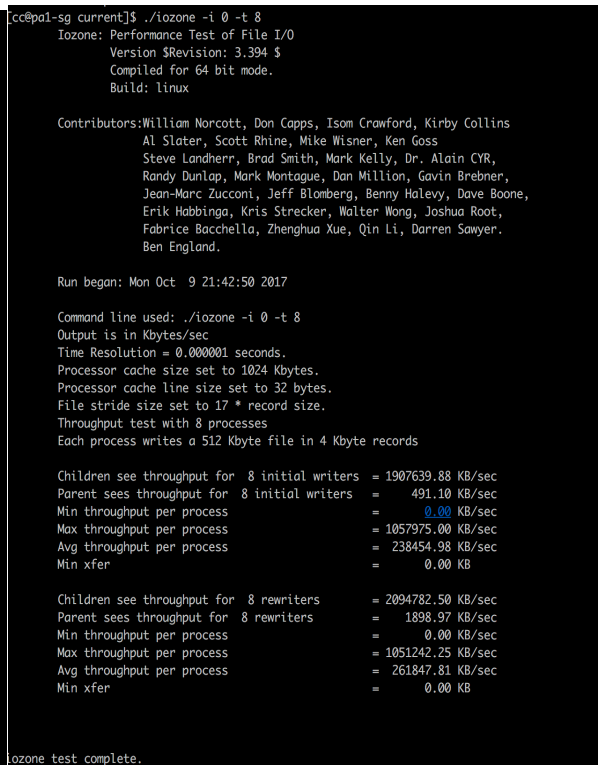
```
[cc@pa1-sg current]$ ./iozone -i 0 -t 1
        Iozone: Performance Test of File I/O
                Version $Revision: 3.394 $
                Compiled for 64 bit mode.
                Build: linux

        Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
                     Al Slater, Scott Rhine, Mike Wisner, Ken Goss
                     Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
                     Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
                     Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
                     Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
                     Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer.
                     Ben England.

        Run began: Mon Oct  9 21:43:09 2017

        Command line used: ./iozone -i 0 -t 1
        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.
        Throughput test with 1 process
        Each process writes a 512 Kbyte file in 4 Kbyte records

        Children see throughput for  1 initial writers  =  850554.06 KB/sec
        Parent sees throughput for  1 initial writers   =    1564.81 KB/sec
        Min throughput per process                      =  850554.06 KB/sec
        Max throughput per process                      =  850554.06 KB/sec
        Avg throughput per process                      =  850554.06 KB/sec
        Min xfer                                        =     512.00 KB

        Children see throughput for  1 rewriters        =  484780.56 KB/sec
        Parent sees throughput for  1 rewriters         =    4776.17 KB/sec
        Min throughput per process                      =  484780.56 KB/sec
        Max throughput per process                      =  484780.56 KB/sec
        Avg throughput per process                      =  484780.56 KB/sec
        Min xfer                                        =     512.00 KB


iozone test complete.
```



```
[cc@pa1-sg current]$ ./iozone -i 0 -t 2
        Iozone: Performance Test of File I/O
                Version $Revision: 3.394 $
                Compiled for 64 bit mode.
                Build: linux

        Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
                     Al Slater, Scott Rhine, Mike Wisner, Ken Goss
                     Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
                     Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
                     Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
                     Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
                     Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer.
                     Ben England.

        Run began: Mon Oct  9 21:42:08 2017

        Command line used: ./iozone -i 0 -t 2
        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.
        Throughput test with 2 processes
        Each process writes a 512 Kbyte file in 4 Kbyte records

        Children see throughput for  2 initial writers  =  847532.88 KB/sec
        Parent sees throughput for  2 initial writers   =     786.70 KB/sec
        Min throughput per process                      =  847532.88 KB/sec
        Max throughput per process                      =  847532.88 KB/sec
        Avg throughput per process                      =  423766.44 KB/sec
        Min xfer                                        =     512.00 KB

        Children see throughput for  2 rewriters        = 2348292.50 KB/sec
        Parent sees throughput for  2 rewriters         =    1321.04 KB/sec
        Min throughput per process                      = 1149120.75 KB/sec
        Max throughput per process                      = 1199171.75 KB/sec
        Avg throughput per process                      = 1174146.25 KB/sec
        Min xfer                                        =     492.00 KB


iozone test complete.
```

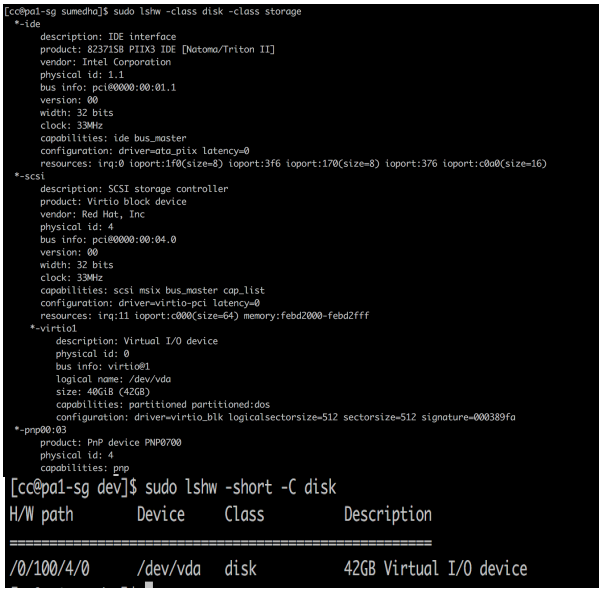


```
iozone test complete.
[cc@pa1-sg current]$ ./iozone -i 0 -t 4
        Iozone: Performance Test of File I/O
                Version $Revision: 3.394 $
                Compiled for 64 bit mode.
                Build: linux

        Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
                     Al Slater, Scott Rhine, Mike Wisner, Ken Goss
                     Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
                     Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
                     Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
                     Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
                     Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer.
                     Ben England.

        Run began: Mon Oct  9 21:42:31 2017

        Command line used: ./iozone -i 0 -t 4
        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.
        Throughput test with 4 processes
        Each process writes a 512 Kbyte file in 4 Kbyte records

        Children see throughput for  4 initial writers  = 1903794.50 KB/sec
        Parent sees throughput for  4 initial writers   =    2541.09 KB/sec
        Min throughput per process                      =  884002.56 KB/sec
        Max throughput per process                      = 1019791.94 KB/sec
        Avg throughput per process                      =  475948.62 KB/sec
        Min xfer                                        =     412.00 KB

        Children see throughput for  4 rewriters        = 1029644.44 KB/sec
        Parent sees throughput for  4 rewriters         =    2309.29 KB/sec
        Min throughput per process                      =       0.00 KB/sec
        Max throughput per process                      =  523258.66 KB/sec
        Avg throughput per process                      =  257411.11 KB/sec
        Min xfer                                        =       0.00 KB


iozone test complete.
```



```
[cc@pa1-sg current]$ ./iozone -i 0 -t 8
        Iozone: Performance Test of File I/O
                Version $Revision: 3.394 $
                Compiled for 64 bit mode.
                Build: linux

        Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
                     Al Slater, Scott Rhine, Mike Wisner, Ken Goss
                     Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
                     Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
                     Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
                     Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
                     Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer.
                     Ben England.

        Run began: Mon Oct  9 21:42:50 2017

        Command line used: ./iozone -i 0 -t 8
        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.
        Throughput test with 8 processes
        Each process writes a 512 Kbyte file in 4 Kbyte records

        Children see throughput for  8 initial writers  = 1907639.88 KB/sec
        Parent sees throughput for  8 initial writers   =     491.10 KB/sec
        Min throughput per process                      =       0.00 KB/sec
        Max throughput per process                      = 1057975.00 KB/sec
        Avg throughput per process                      =  238454.98 KB/sec
        Min xfer                                        =       0.00 KB

        Children see throughput for  8 rewriters        = 2094782.50 KB/sec
        Parent sees throughput for  8 rewriters         =    1898.97 KB/sec
        Min throughput per process                      =       0.00 KB/sec
        Max throughput per process                      = 1051242.25 KB/sec
        Avg throughput per process                      =  261847.81 KB/sec
        Min xfer                                        =       0.00 KB


iozone test complete.
```

- The theoretical performance is generally advertised by the manufacturer.
  After trying many commands, this data I got which just specifies the size of the disk.



The performance that we found for Seagate ST9250610NS is:
Average Latency: 4.16 ms, 7200 RPM and 115 MB/sec data transfer rate.