CS553 Programming Assignment #1

Benchmarking – Performance Evaluation

Divya Krishnamoorthy – A20356333

System Details:

Amazon AWS – t2.micro instance

```
[ec2-user@ip-172-31-62-237 ~]$ more /proc/cpuinfo
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 63
model name      : Intel(R) Xeon(R) CPU E5-2676 v3 @ 2.40GHz
stepping        : 2
microcode       : 0x25
cpu MHz         : 2394.530
cache size      : 30720 KB
physical id     : 0
siblings        : 1
core id         : 0
cpu cores       : 1
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 13
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov
pat pse36 clflush mmx fxsr sse sse2 ht syscall nx rdtscp lm constant_tsc rep_goo
d nopl xtopology eagerfpu pni pclmulqdq ssse3 fma cx16 pcid sse4_1 sse4_2 x2apic
 movbe popcnt tsc_deadline_timer aes xsave avx f16c rdrand hypervisor lahf_lm ab
```

```
[ec2-user@ip-172-31-62-237 ~]$ lscpu
Architecture:          x86_64
CPU op-mode(s):        32-bit, 64-bit
Byte Order:            Little Endian
CPU(s):                1
On-line CPU(s) list:   0
Thread(s) per core:    1
Core(s) per socket:    1
Socket(s):             1
NUMA node(s):          1
Vendor ID:             GenuineIntel
CPU family:            6
Model:                 63
Model name:            Intel(R) Xeon(R) CPU E5-2676 v3 @ 2.40GHz
Stepping:              2
CPU MHz:               2394.530
BogoMIPS:              4789.06
Hypervisor vendor:     Xen
Virtualization type:   full
L1d cache:             32K
L1i cache:             32K
L2 cache:              256K
L3 cache:              30720K
```

CPU Benchmarking

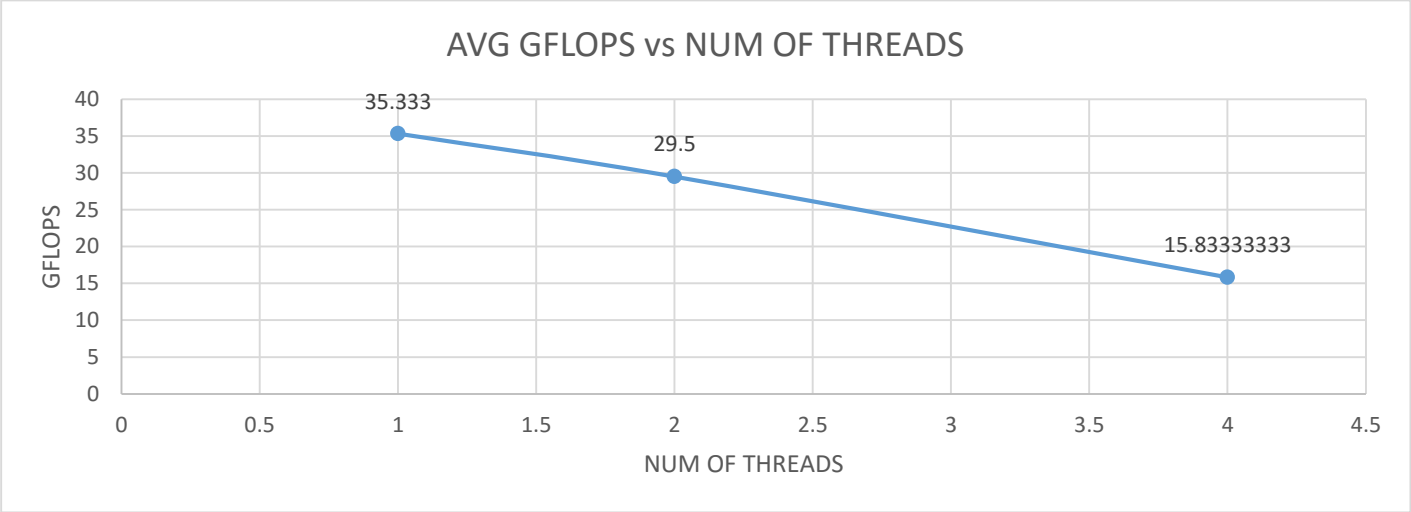
Theoretical peak performance = Frequency*no.of cores*IPC =2.4Ghz * 1* 16= 38.4 GFLOPS

1) GFLOPS

CPU GFLOPS Bench Mark Results :

Problem Size: 10000000000

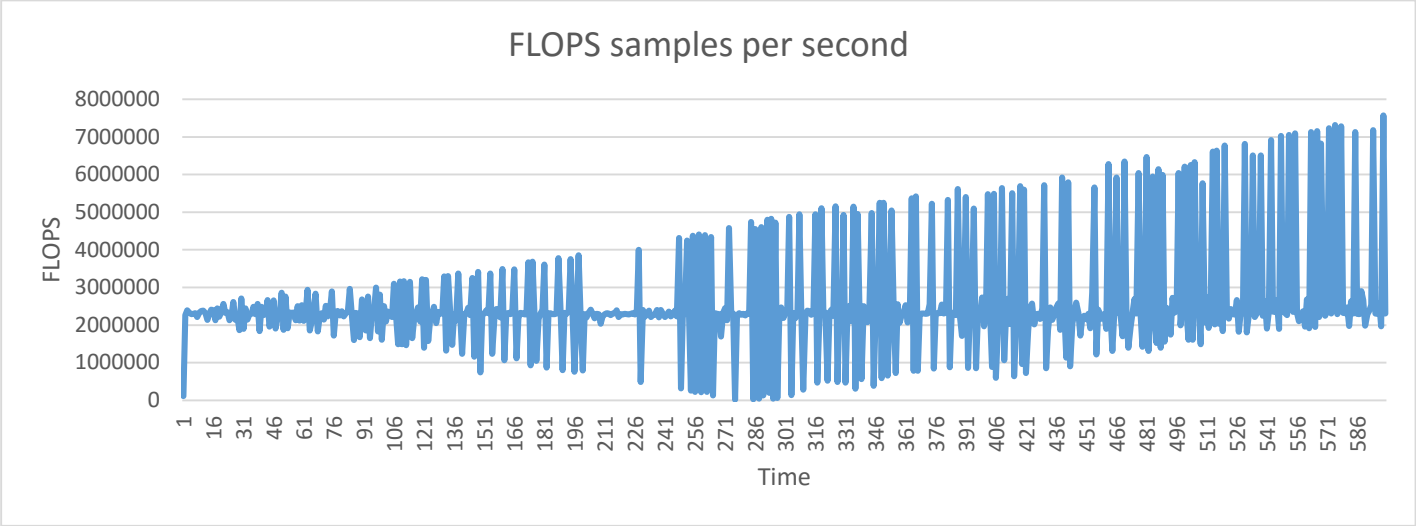
Thread Count	Iteration 1	Iteration 2	Iteration 3	Average	Standard Deviation
1	38	34	34	35.333	2.309401077
2	29.5	29.5	29.5	29.5	0
4	16	15.25	16.25	15.8333333	0.5204165



The Peak performance is achieved in the case of single thread with 35.333 GFLOPS

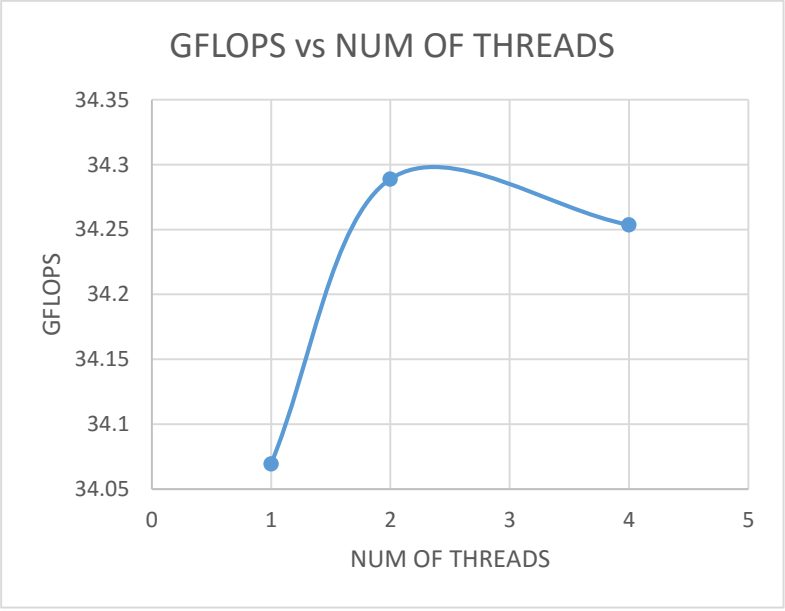
The efficiency of the system = (35.333/38.4)*100 =92.01%

FLOPS – Samples per second over a period of 10 minutes



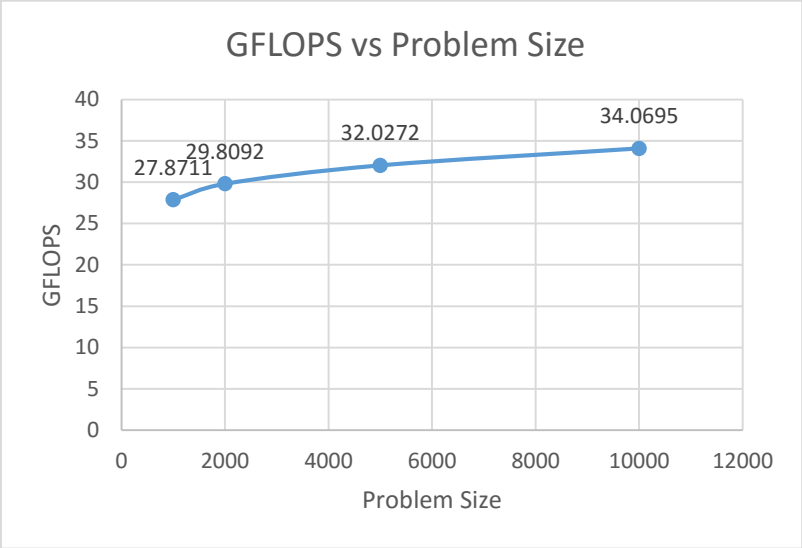
LINPACK BENCHMARK

Problem Size	Thread Count	Average GFLOPS
10000	1	34.0695
10000	2	34.2888
10000	4	34.2535



Problem Size	Thread Count	Average GFLOPS
1000	1	27.8711
2000	1	29.8092

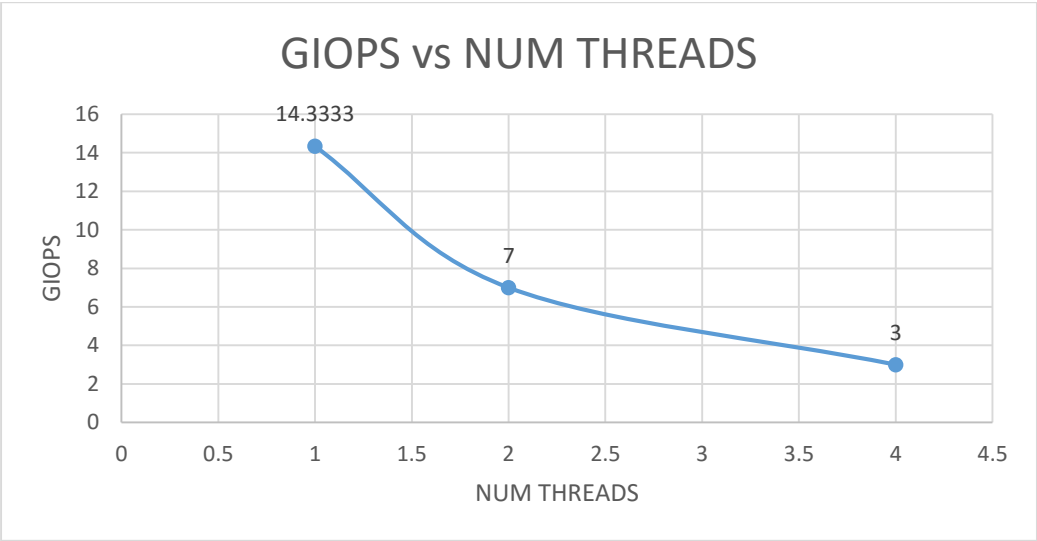
5000	1	32.0272
10000	1	34.0695



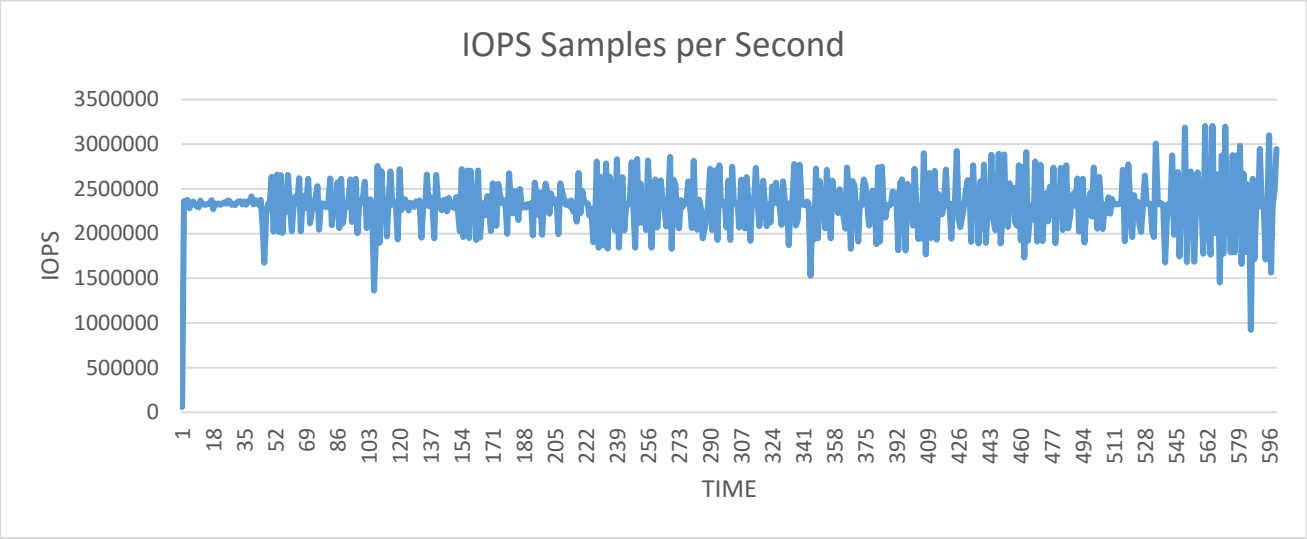
Efficiency with LINPACK = (34.0695/38.4) *100 = 88.72%

2) GIOPS

Thread Count	Iteration 1	Iteration 2	Iteration 3	Average	Standard Deviation
1	14	15	14	14.3333333	0.577350269
2	7	7	7	7	0
4	3	3	3	3	0



IOPS – Samples per second over a period of 10 minutes



DISK BENCHMARKING

For EBS Storage of t2.micro instance the theoretical peak performance could be estimated to be around 160Mbytes/Sec

- **THROUGHPUT is measured in Megabytes/Second**
- **LATENCY is measured in milliseconds**

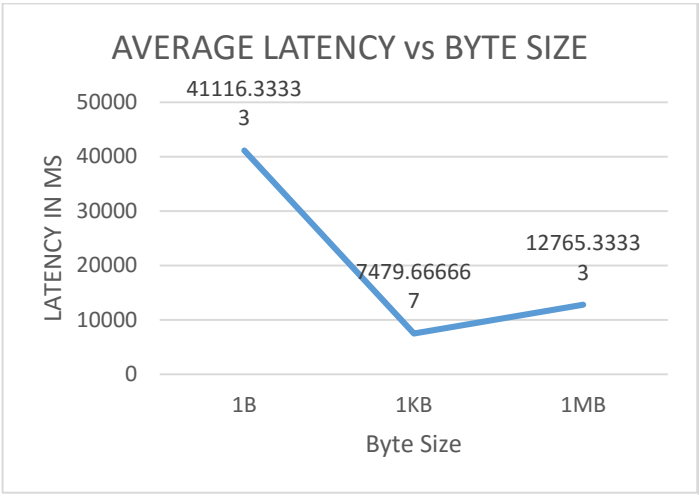
1) SEQUENTIAL READ

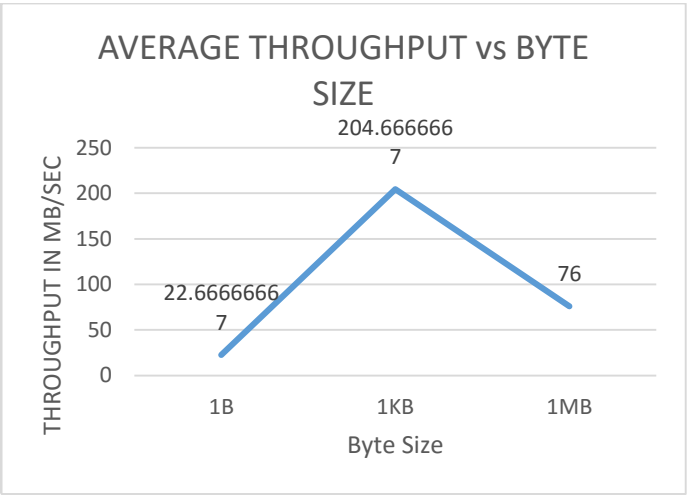
THREAD COUNT =1	**SEQUENTIAL READ**	Fille Size =1000000000B

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	40825	41030	41494	41116.33333	342.754042
1KB	2547	5419	14473	7479.666667	6224.31758
1MB	11731	11083	15482	12765.33333	2374.907226

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE(MBYTES/SEC)	STANDARD DEVIATION
1B	23	23	22	22.66666667	0.577350269
1KB	374	175	65	204.6666667	156.6216247
1MB	81	86	61	76	123.5687212

Peak performance is achieved with 1KB Block size with a Latency of 7479 ms and Throughput of 204.667Mbytes/sec



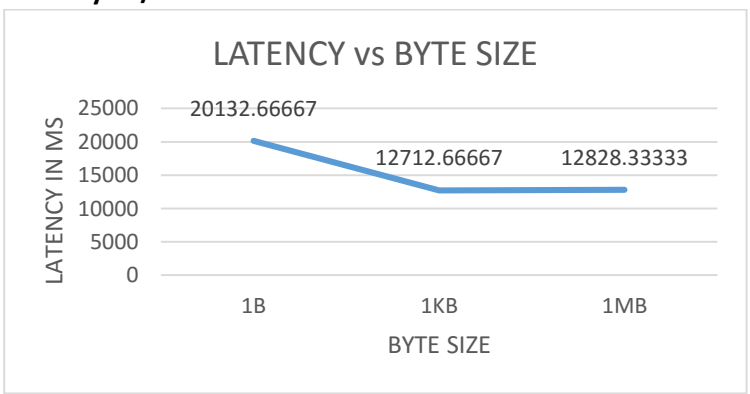


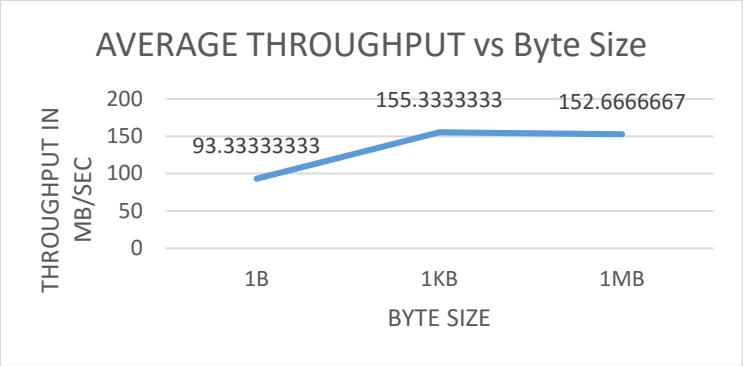
THREAD COUNT =2	SEQUENTIAL READ

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	20019	20443	19936	20132.66667	271.941783
1KB	14481	14471	9186	12712.66667	3054.187017
1MB	15492	13137	9856	12828.33333	2830.650161

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	94	92	94	93.33333333	1.154700538
1KB	130	130	206	155.3333333	43.87862046
1MB	122	144	192	152.6666667	66.00609018

Peak performance is achieved with 1KB Block size with a Latency of 12712 ms and Throughput of 206Mbytes/sec.



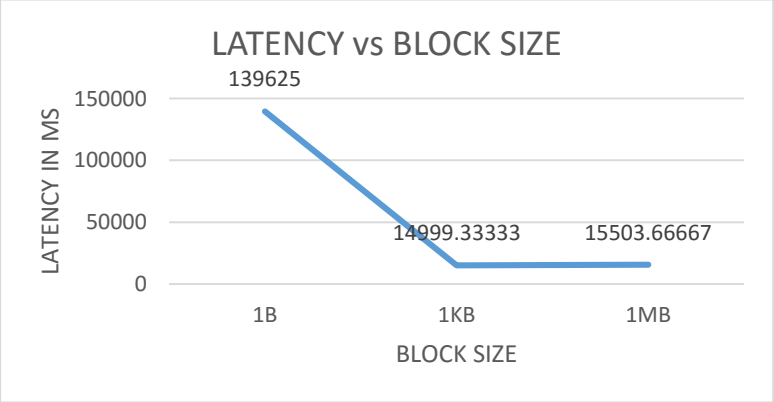


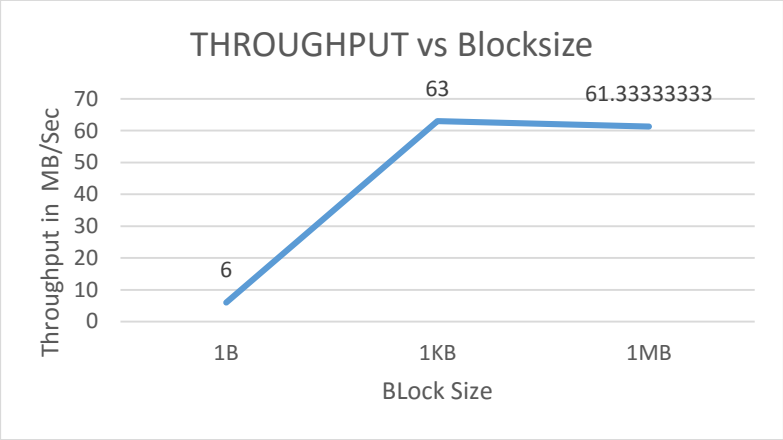
2) SEQUENTIAL WRITE

THREAD COUNT =1	**SEQUENTIAL WRITE**				
BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	140440	139810	138625	139625	1673.963446
1KB	15011	14995	14992	14999.33333	10.21436896
1MB	15315	15602	15594	15503.66667	163.4390814

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	6	6	6	6	0
1KB	63	63	63	63	0
1MB	62	61	61	61.33333333	0.577350269

Peak performance is achieved with 1KB Block size with a Latency of 14999.33 ms and Throughput of 63Mbytes/sec.

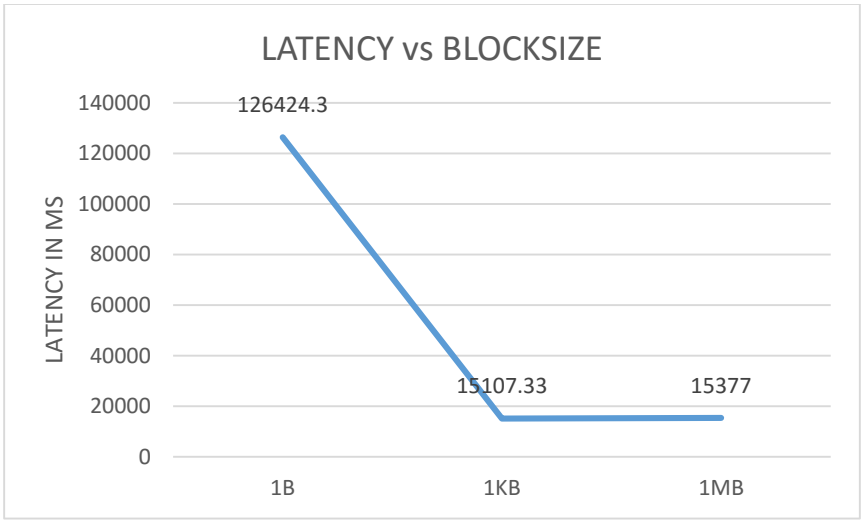


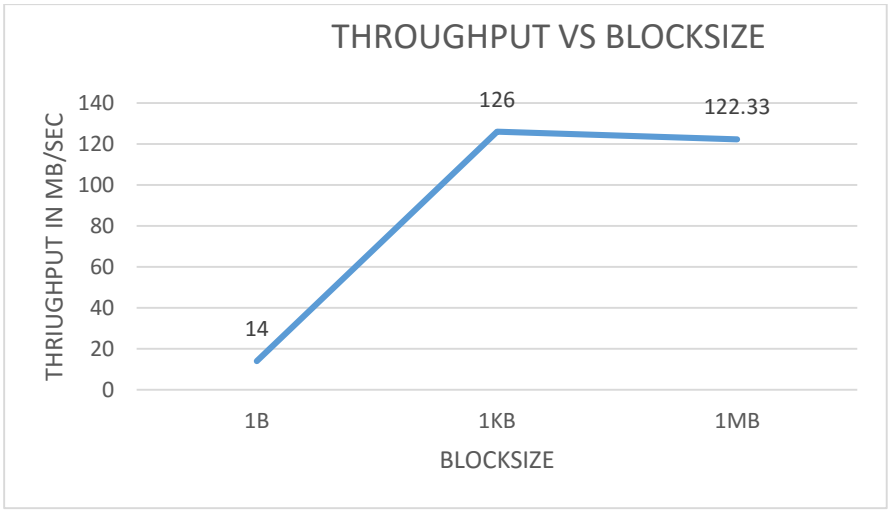


THREAD COUNT =2	**SEQUENTIAL WRITE**				
BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	123462	131534	124277	126424.3	3628.367524
1KB	15351	14839	15132	15107.33	256.8897299
1MB	15384	15368	15379	15377	8.185352772

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	14	14	14	14	0
1KB	124	128	126	126	2
1MB	122	123	122	122.3333	0.577350269

Peak performance is achieved with 1KB Block size with a Latency of 15107 ms and Throughput of 126Mbytes/sec.





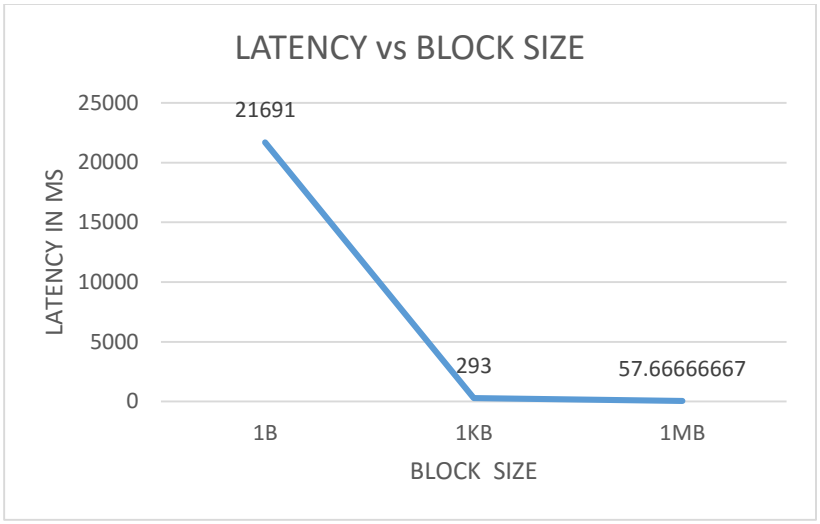
3) RANDOM READ

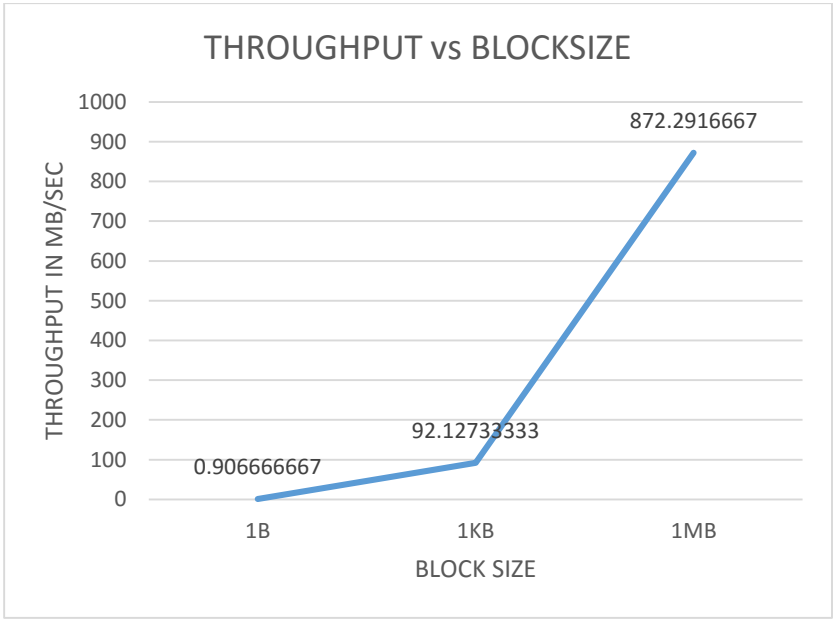
THREAD COUNT =1	**RANDOM READ**				

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	21338	21458	22277	21691	417.2505243
1KB	169	553	157	293	225.2465316
1MB	18	141	14	57.66666667	72.19649114

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	0.9214	0.916	0.8826	0.906666667	0.021016501
1KB	115.915	35.555	124.912	92.12733333	49.19916845
1MB	1077.95	139.301	1399.624	872.2916667	654.8473323

Peak performance is achieved with 1MB Block size with a Latency of 57.667 ms and Throughput of 872.291 Mbytes/sec.

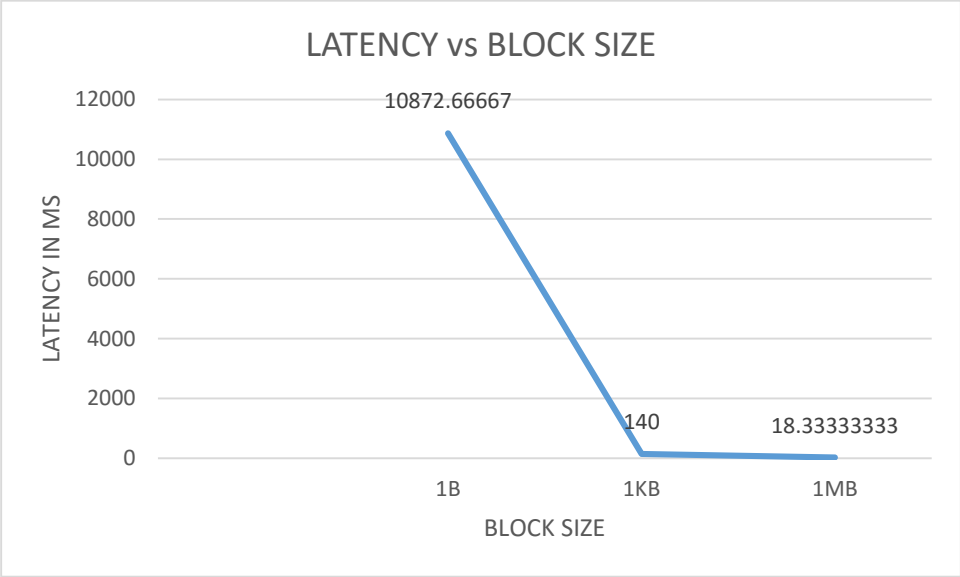

LATENCY vs BLOCK SIZE
LATENCY IN MS
25000
20000
15000
10000
5000
0
21691
293
57.66666667
1B
1KB
1MB
BLOCK SIZE

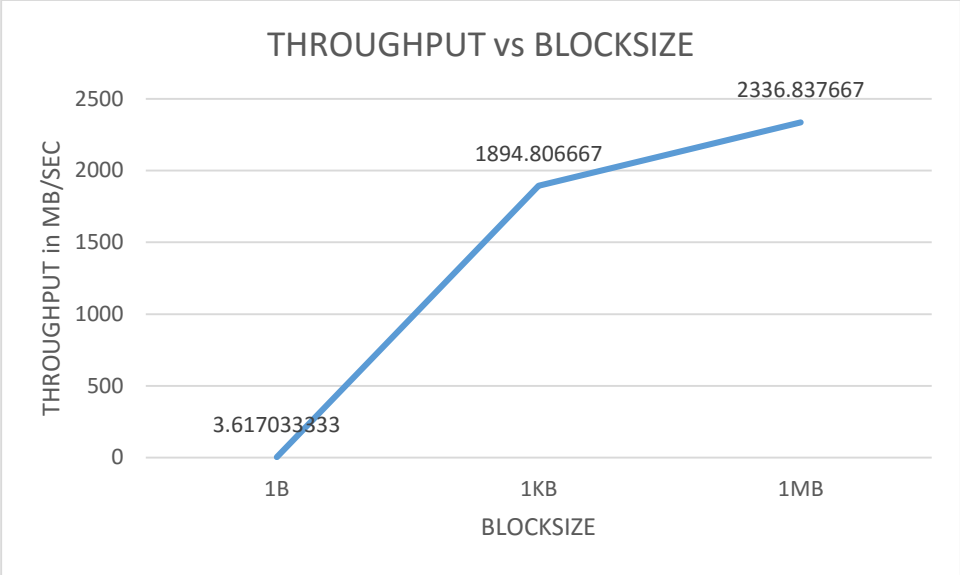

THROUGHPUT vs BLOCKSIZE
THROUGHPUT IN MB/SEC
1000
900
800
700
600
500
400
300
200
100
0
872.2916667
92.12733333
0.906666667
1B
1KB
1MB
BLOCK SIZE

THREAD COUNT =2	**RANDOM READ**				

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	11075	10669	10874	10872.66667	165.7514873
1KB	141	152	127	140	12.52996409
1MB	17	20	18	18.33333333	1.527525232

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	3.55	3.6861	3.615	3.617033333	0.06807278
1KB	2108	2060.32	1516.1	1894.806667	328.8349132
1MB	2353.78	2137.093	2519.64	2336.837667	191.8354342





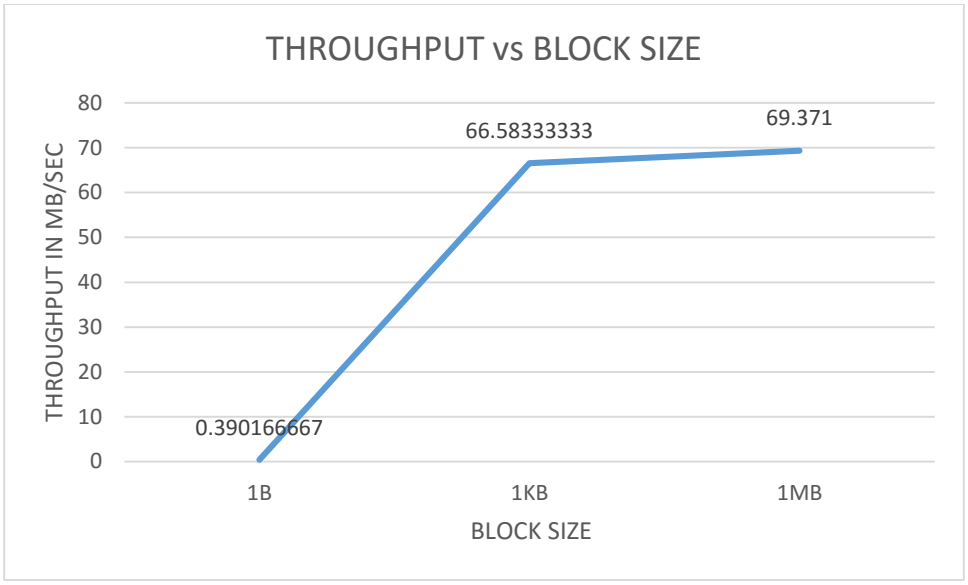
4) RANDOM WRITE

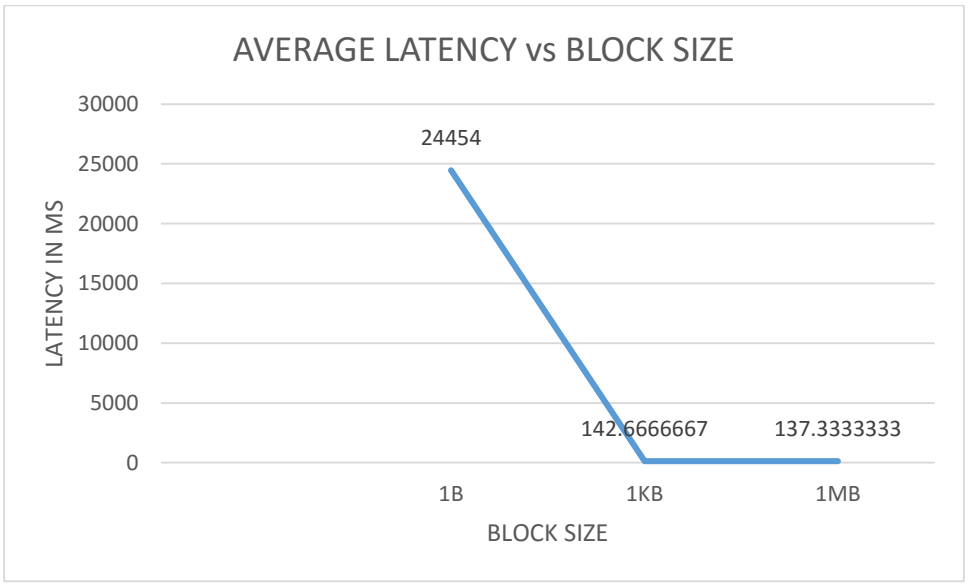
THREAD COUNT =1	**RANDOM WRITE**				

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	24199	25324	23839	24454	632.4950593
1KB	146	140	142	142.6666667	3.055050463
1MB	128	134	150	137.3333333	11.37248141

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	0.394	0.3765	0.4	0.390166667	0.012209969
1KB	64.993	67.74	67.017	66.58333333	1.423921463
1MB	74.026	70.738	63.349	69.371	5.468189737

Peak performance is achieved with 1MB Block size with a Latency of 137.33 ms and Throughput of 69.371Mbytes/sec


THROUGHPUT vs BLOCK SIZE
THROUGHPUT IN MB/SEC
80
70
60
50
40
30
20
10
0
66.58333333
69.371
0.390166667
1B
1KB
1MB
BLOCK SIZE

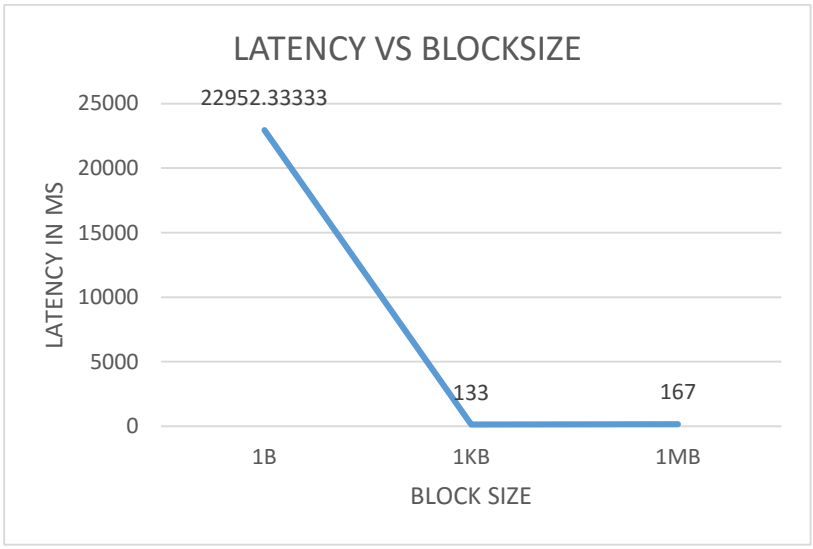

AVERAGE LATENCY vs BLOCK SIZE
LATENCY IN MS
30000
25000
20000
15000
10000
5000
0
24454
142.6666667
137.3333333
1B
1KB
1MB
BLOCK SIZE

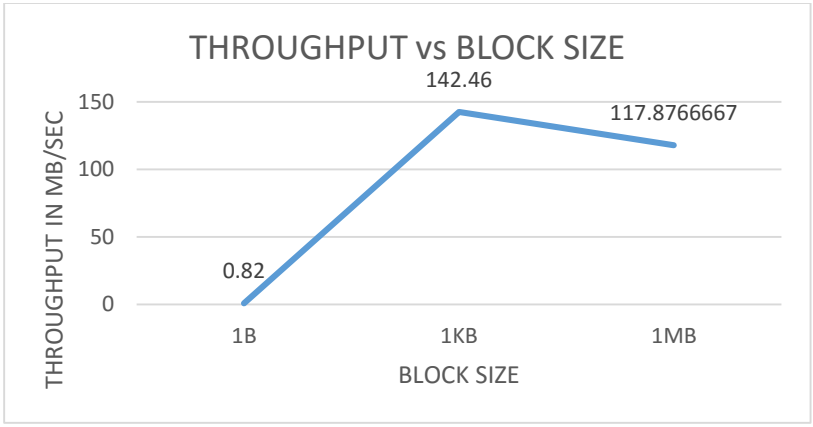
THREAD COUNT =2	**RANDOM WRITE**				

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	23257	22790	22810	22952.33333	215.5865384
1KB	133	129	137	133	4
1MB	174	163	164	167	6.08276253

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	0.81	0.82	0.83	0.82	0.01
1KB	143	146	138.38	142.46	3.838593492
1MB	114	123	116.63	117.8766667	4.627702814

Peak performance is achieved with 1KB Block size with a Latency of 133 ms and Throughput of 142.46Mbytes/sec





NETWORK BENCHMARKING

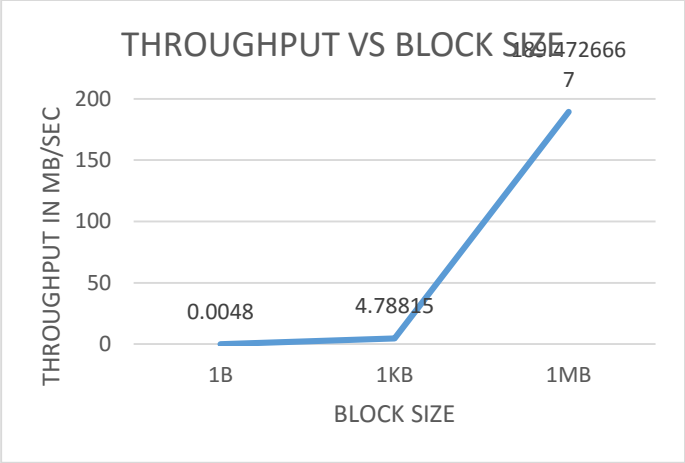
- **THROUGHPUT is measured in Megabytes/Second**
- 1 MegaByte/Second = 8 Megabits/seconds
- **Latency is measured in milliseconds**

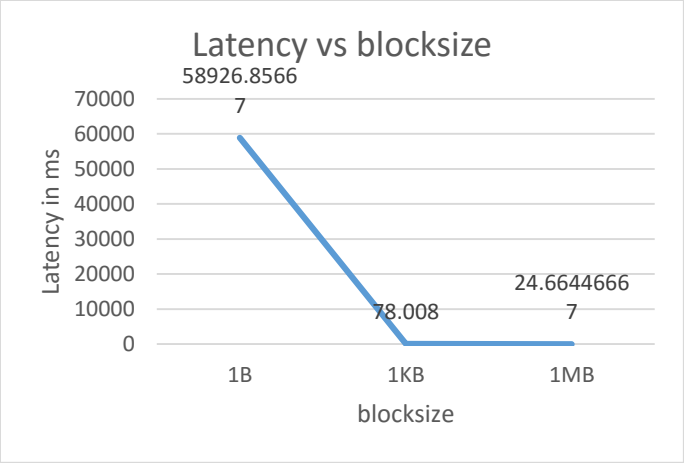
THREAD COUNT =1	**TCP BENCHMARK**

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	47439.14	64953	64388.43	58926.85667	8126.311606
1KB	50.284	67.11	116.63	78.008	34.48945827
64KB	19.205	30.494	24.2944	24.66446667	5.653591094

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	0.002634	0.0019	0.00194	0.002158	0.000412713
1KB	2.485	1.8623	1.07174	1.806346667	0.708289516
64KB	6.508	4.099	5.145	5.250666667	1.207971164

Peak performance is achieved with 64KB Block size with a Latency of 24.664 ms and Throughput of 5.25Mbytes/sec



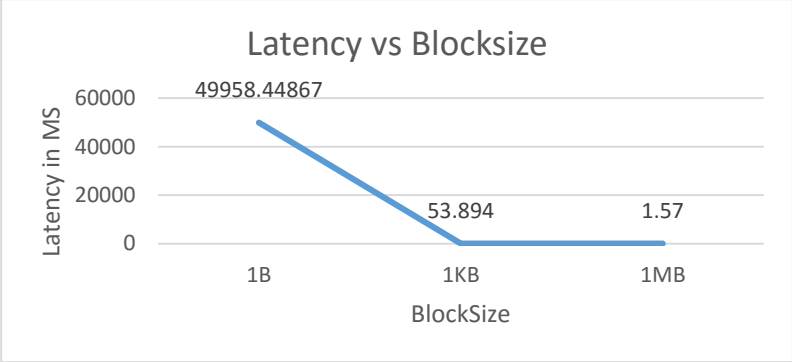


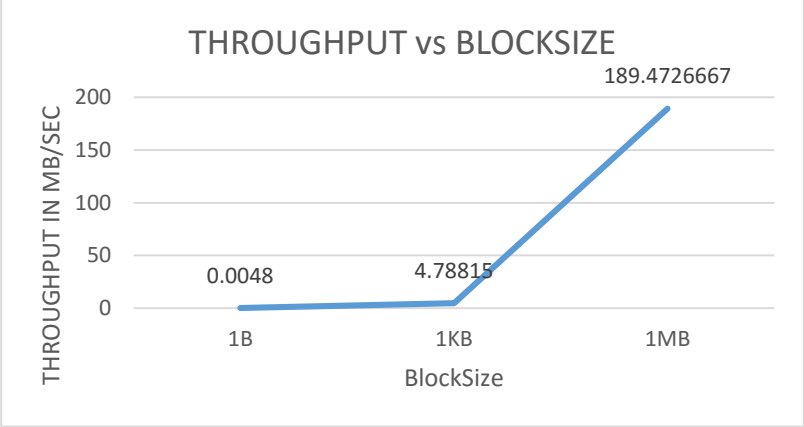
THREAD COUNT =2	**TCP BENCHMARK**

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	41551.056	55209.29	53115	49958.44867	6006.091421
1KB	46.772	63.58	51.33	53.894	8.692398288
64KB	1.75	1.87	1.09	1.57	0.42

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	0.006	0.0044	0.004	0.0048	0.001058301
1KB	5.4	3.99445	4.97	4.78815	0.720204671
64KB	147.28	190.466	230.672	189.4726667	41.70487321

Peak performance is achieved with 64KB Block size with a Latency of 1.57ms and Throughput of 189.472Mbytes/sec

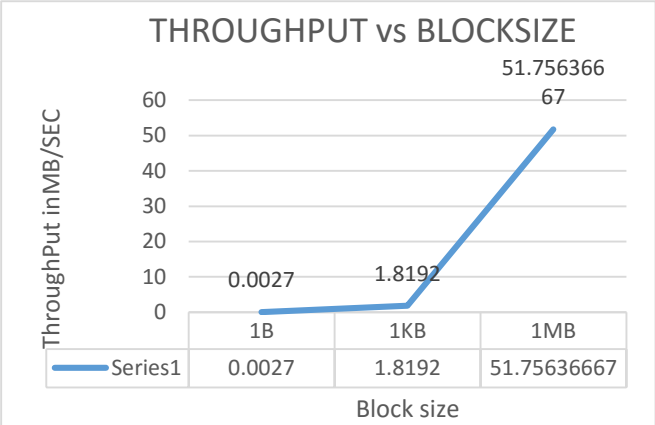


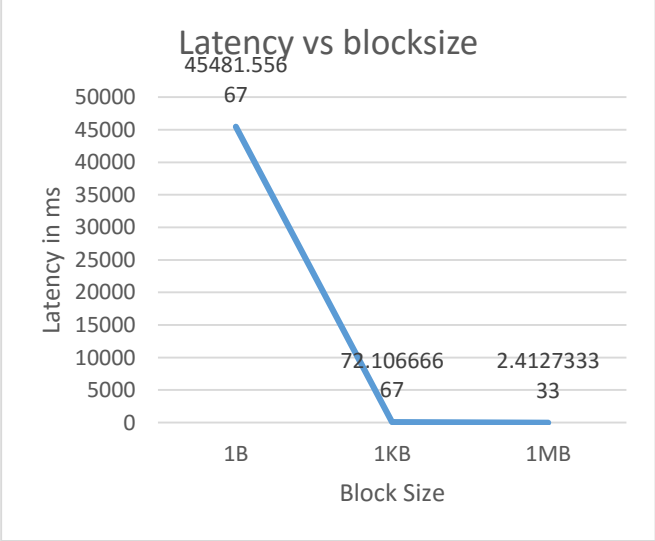


UDP BENCHMARKING

THREAD COUNT =1		UDP BENCHMARK			
BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	46173.76	45331.51	44939.4	45481.55667	514.9735618
1KB	88.18	76.16	51.98	72.10666667	18.43724853
64KB	2.371	2.4602	2.407	2.412733333	0.044875532
BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	0.0027	0.0027	0.0027	0.0027	5.31148E-19
1KB	1.4161	1.6395	2.402	1.8192	0.516932075
64KB	52.648	50.75	51.8711	51.75636667	0.95418751

Peak performance is achieved with 1MB Block size with a Latency of 2.42ms and Throughput of 51.746 Mbytes/sec



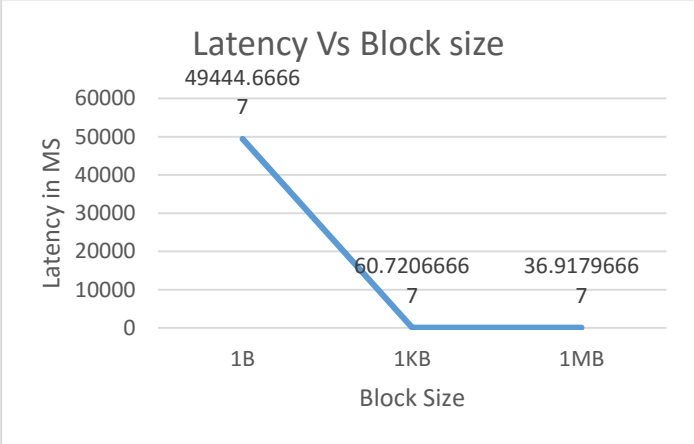


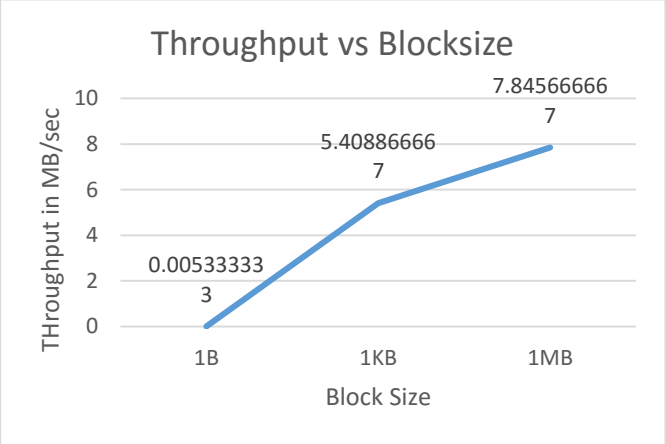
THREAD COUNT =2	**UDP BENCHMARK**				

BYTE SIZE	LATENCY1(ms)	LATENCY2(ms)	LATENCY3(ms)	AVERAGE	STANDARD DEVIATION
1B	49111	50105	49118	49444.66667	466.9349229
1KB	60.822	60.51	60.83	60.72066667	0.182486529
64KB	37.2019	36.204	37.348	36.91796667	0.622613526

BYTE SIZE	THROUGHPUT1	THROUGHPUT2	THROUGHPUT3	AVERAGE	STANDARD DEVIATION
1B	0.005	0.006	0.005	0.005333333	0.00057735
1KB	5.1366	5.167	5.923	5.408866667	0.4455119
64KB	7.78	7.905	7.852	7.845666667	0.062740205

Peak performance is achieved with 1MB Block size with a Latency of 36.91ms and Throughput of 7.845 Mbytes/sec





IPERF:

```
[ec2-user@ip-172-31-55-233 src]$ ./iperf -c 172.31.62.237
------------------------------------------------------------
Client connecting to 172.31.62.237, TCP port 5001
TCP window size:  325 KByte (default)
------------------------------------------------------------
[  3] local 172.31.55.233 port 38961 connected with 172.31.62.237 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.05 GBytes   898 Mbits/sec
[ec2-user@ip-172-31-55-233 src]$ ./iperf -c 172.31.62.237
------------------------------------------------------------
Client connecting to 172.31.62.237, TCP port 5001
TCP window size:  325 KByte (default)
------------------------------------------------------------
[  3] local 172.31.55.233 port 38962 connected with 172.31.62.237 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.04 GBytes   894 Mbits/sec
[ec2-user@ip-172-31-55-233 src]$
```

```
[ec2-user@ip-172-31-55-233 src]$ ./iperf -c 172.31.62.237 -u -b 100m
------------------------------------------------------------
Client connecting to 172.31.62.237, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:  208 KByte (default)
------------------------------------------------------------
[  3] local 172.31.55.233 port 47905 connected with 172.31.62.237 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec   120 MBytes   100 Mbits/sec
[  3] Sent 85406 datagrams
[  3] Server Report:
[  3]  0.0-10.0 sec   119 MBytes   100 Mbits/sec   0.073 ms  176/85405 (0.21%)
[  3]  0.0-10.0 sec  1 datagrams received out-of-order
[ec2-user@ip-172-31-55-233 src]$ ./iperf -c 172.31.62.237 -u -b 100m
------------------------------------------------------------
Client connecting to 172.31.62.237, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:  208 KByte (default)
------------------------------------------------------------
[  3] local 172.31.55.233 port 39087 connected with 172.31.62.237 port 5001
```