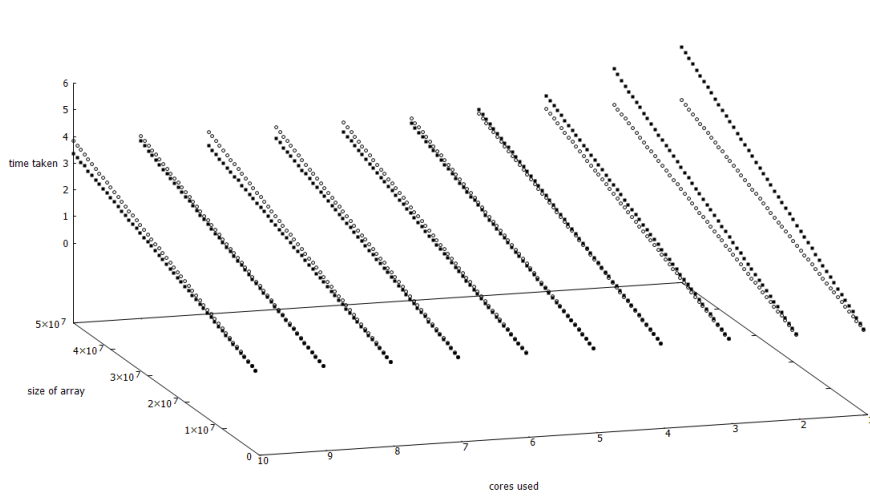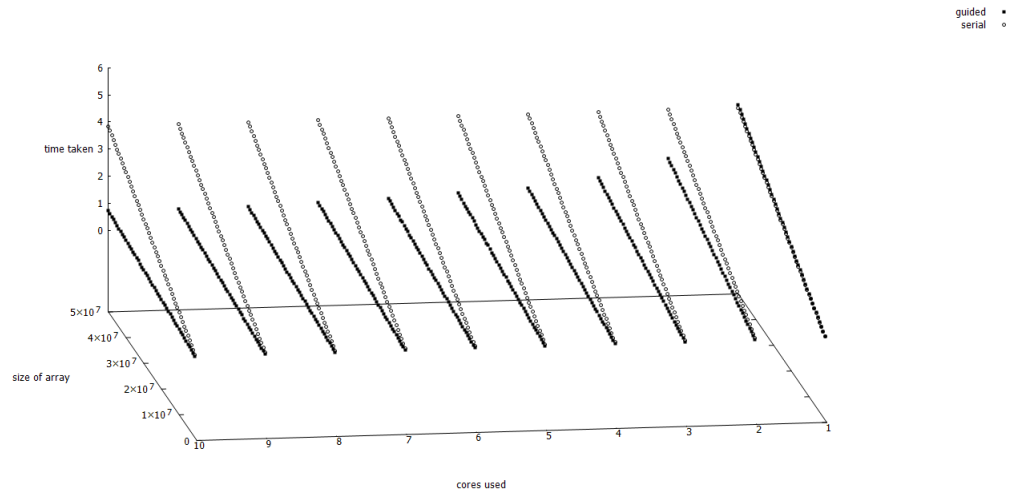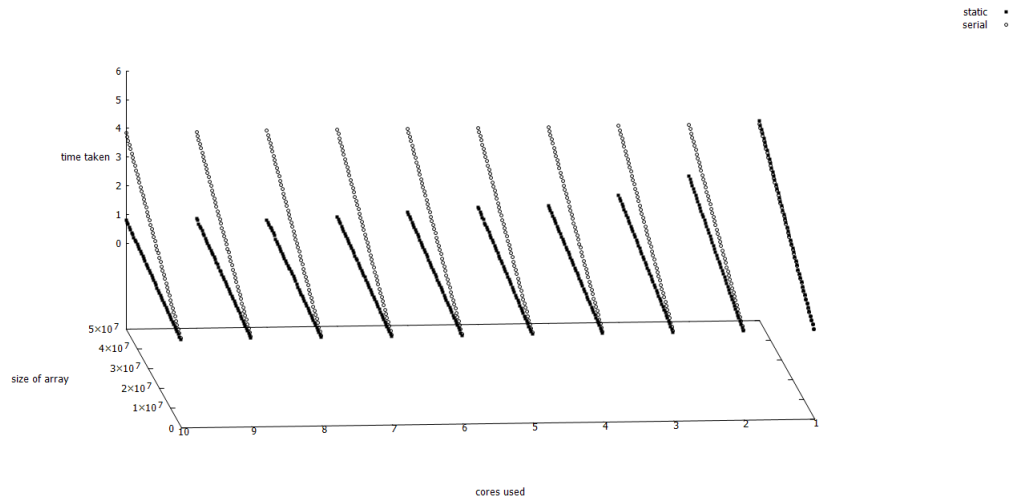Assignment 2
Comparison of Serial implementation vs OpenMP
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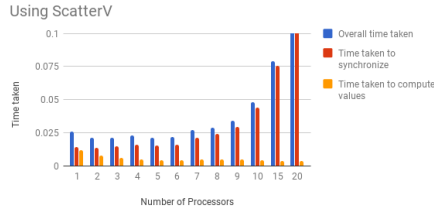
1 Results OpenMP

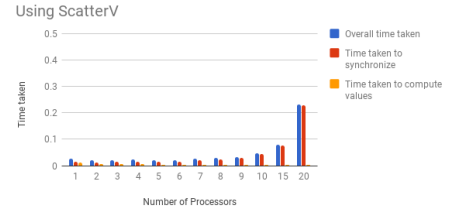| Array Size	# of cores	Static vs Serial	Guided vs Serial	Dynamic vs Serial
1000000	1	5.15% Slower	2.8% Slower	34.22% Slower
50000000	1	2.44% Slower	2.89% Slower	34.19% Slower
1000000	2	86.58% Faster	85.55% Faster	25.28% Slower
50000000	2	87.09% Faster	86.62% Faster	25.88% Slower
1000000	3	164.64% Faster	164.84% Faster	12.38% Slower
50000000	3	170.02% Faster	169.64% Faster	11.68% Slower
1000000	4	236.21% Faster	234.87% Faster	4.4% Slower
50000000	4	246.3% Faster	245.07% Faster	3.98% Slower
1000000	5	235.65% Faster	277.3% Faster	4.85% Faster
50000000	5	258.52% Faster	278.54% Faster	5.27% Faster
1000000	6	292.68% Faster	312.04% Faster	10.01% Faster
50000000	6	308.79% Faster	336.38% Faster	10.19% Faster
1000000	7	348.89% Faster	362.41% Faster	10.77% Faster
50000000	7	370.24% Faster	376.98% Faster	12.71% Faster
1000000	8	401.28% Faster	400.07% Faster	15.04% Faster
50000000	8	428.88% Faster	427.96% Faster	15.87% Faster
1000000	9	245.03% Faster	404.31% Faster	5.04% Faster
50000000	9	369.78% Faster	431.16% Faster	5.11% Faster
1000000	10	276.76% Faster	342.62% Faster	13.23% Faster
50000000	10	390.43% Faster	421.92% Faster	14.1% Faster

2 Results MPI

(a) Process number 1-15

(b) Process number 1-20

Figure 1: Data from Appendix 6.5

3 OpenMP : Different types of scheduling

3.1 Static

When a user specifies their task to be sent to multiple threads using static scheduling it is split into equal chunks depending on the amount of threads the user would like to use, these chunks are then sent to each thread who then carry out the jobs within the chunks. One advantage to this type of scheduling technique is that the overhead is low due to only having to work out the size of the chunks being sent to each thread additionally due to the way this scheduling technique works we do not have to wait for tasks to be completed by threads before sending more jobs which means less communication which means more processing time, however it performs badly on jobs that have a large standard deviation on execution time.

3.2 Dynamic

When a user specifies their information to be sent to multiple threads using dynamic scheduling it is split into chunks of "N" size, by default N is 1 and therefore each thread is sent 1 job each, once the thread completes it's job it then returns and requests another job (no matter the order the jobs were sent initially).
Suppose that there are two threads who want to complete 4 jobs, each requests a job, and starts it, assume that thread 2 completes it's job first, and therefore requests another job, now consider the possiblity that thread 2 also completes its second job before thread 1 completes its first job, thread 2 would now be sent another job, this differs from static scheduling where thread 1 and 2 would receave 2 jobs each. This scheduling excels at jobs that take different amounts of time to complete as showin the the example above, where job 1 takes significantly more time to complete than job 2, 3 and 4.

3.3 Guided

When using this sceduling method we distribute jobs unevenly in a specific fashion, each thread is given a chunk of the main problem we are trying to solve, such that we have jobs still left to complete, after a thread completes its job, we send a chunk of smaller size than previously given to any thread, this continues until all jobs have been completed, however we can see that in this fashion we allow for more communication towards the end of a group of tasks allowing for it to perform well on problems which have a small standard deviation on jobs at the start of a group and a large deviation towards the end of the group.

To show this suppose we have 10 jobs, and 3 threads, suppose we send
3 jobs to thread 1,
3 jobs to thread 2,
2 jobs to thread 3,
Suppose that thread 3 completes all jobs it was given before thread 1 or thread 2 completed theirs,
1 job to thread 3,
Suppose that thread 2 completes all jobs given,
1 job to thread 2

4   Analysis

From the results we can see that two of the three different scheduling techniques performed strictly better than their serial counterparts, both guided and static performing similarly, however when we look at dynamic we can see that the scheduling technique actually performed worse on smaller core sizes, I hypothesise that this may be due to the overhead required by each core to request information, each block of information being only of length one by default, we can see however at larger core sizes the parallel version actually comes out slightly ahead, this is because the time saved by splitting the information between threads actually overcomes the loss due to requests.

Now looking at static and guided, we can see that they performed similarly this is what we would expect, since the only difference is that guided "adjusts" to accommodate imbalanced towards the end of a group of problems, since the problem has the same runtime of each this should only be used a few times, interestingly enough the speed for guided was generally better than that of serial despite the same number of operations being carried out be each process, it would be interesting to look into why this may be, and retesting may be required to check that it wasn't caused by how each type of scheduling technique was time sliced.

Additionally when comparing results from our implementation of MPI for the same problem we can see that openMP significantly outperfromed MPI, this is due to the fact that accessing shared memory is magnitutes quicker than sending data between nodes and therefore any communication within MPI becomes the largest factor in runtime by the same point openMP is almost not effected by communication due to the fact of shared memory.

However OpenMP is limited to amount of core's within a machine whereas MPI is restricted by the amount of machines in a cluster and therefore can be expended infinately. We can gain the benefit of both of these tools using MPI to split data between within a cluster and then use openmp to split data on a specific machine in the cluster.

Finally I did test this on higher process's however due to the machine that I was working on only containing 8 cores it became ineffective to add more cores after this.

5   Future research

It would be interesting to look into how different sub categories of each scheduler effects performance of that scheduler for example instead of splitting in static scheduling on Size/process's it would be interesting to look at what happens if we were to decrease the chunks such that multiple are sent.

6 Appendix

6.1 Serial

Array Size — Amount of Cores — Time taken

```
1000000      1     0.076746
2000000      1     0.153803
3000000      1     0.230841
4000000      1     0.307905
5000000      1     0.384589
6000000      1     0.461228
7000000      1     0.538247
8000000      1     0.614654
9000000      1     0.691739
10000000     1     0.768908
11000000     1     0.845954
12000000     1     0.923299
13000000     1     1.000577
14000000     1     1.078217
15000000     1     1.154019
16000000     1     1.231220
17000000     1     1.308151
18000000     1     1.386996
19000000     1     1.465055
20000000     1     1.539991
21000000     1     1.632588
22000000     1     1.695021
23000000     1     1.771011
24000000     1     1.847788
25000000     1     1.926019
26000000     1     2.001719
27000000     1     2.078498
28000000     1     2.155805
29000000     1     2.232671
30000000     1     2.308913
31000000     1     2.386047
32000000     1     2.468482
33000000     1     2.540921
34000000     1     2.618666
35000000     1     2.694065
36000000     1     2.773635
37000000     1     2.849109
38000000     1     2.925690
39000000     1     3.015098
40000000     1     3.086023
41000000     1     3.157382
42000000     1     3.237627
43000000     1     3.312711
44000000     1     3.389506
45000000     1     3.464515
46000000     1     3.543844
47000000     1     3.622308
48000000     1     3.694698
49000000     1     3.771356
50000000     1     3.848605
```

6.2 Guided

Array Size — Amount of Cores — Time taken

```
1000000      1     0.078960
2000000      1     0.158276
3000000      1     0.237474
4000000      1     0.316792
5000000      1     0.396144
6000000      1     0.475142
7000000      1     0.553861
8000000      1     0.632676
9000000      1     0.712191
10000000     1     0.791590
11000000     1     0.870567
12000000     1     0.949639
13000000     1     1.029180
14000000     1     1.109068
15000000     1     1.188445
16000000     1     1.267846
17000000     1     1.346982
18000000     1     1.426654
19000000     1     1.505781
20000000     1     1.584571
21000000     1     1.664198
22000000     1     1.743264
23000000     1     1.822587
24000000     1     1.903166
25000000     1     1.980671
26000000     1     2.060494
27000000     1     2.139317
28000000     1     2.218535
29000000     1     2.297962
30000000     1     2.377012
31000000     1     2.455686
32000000     1     2.534480
33000000     1     2.615027
34000000     1     2.694348
35000000     1     2.772312
36000000     1     2.851712
37000000     1     2.931541
38000000     1     3.009856
39000000     1     3.090642
40000000     1     3.167258
41000000     1     3.248023
```

42000000	1	3.327078
43000000	1	3.404070
44000000	1	3.483231
45000000	1	3.563401
46000000	1	3.642986
47000000	1	3.720911
48000000	1	3.802374
49000000	1	3.880266
50000000	1	3.963309
1000000	2	0.041362
2000000	2	0.082754
3000000	2	0.124662
4000000	2	0.166325
5000000	2	0.207698
6000000	2	0.247841
7000000	2	0.289852
8000000	2	0.329491
9000000	2	0.373208
10000000	2	0.414446
11000000	2	0.453682
12000000	2	0.495412
13000000	2	0.536146
14000000	2	0.577861
15000000	2	0.618595
16000000	2	0.660210
17000000	2	0.702675
18000000	2	0.742370
19000000	2	0.784432
20000000	2	0.825155
21000000	2	0.868398
22000000	2	0.908353
23000000	2	0.954625
24000000	2	0.989379
25000000	2	1.031290
26000000	2	1.075310
27000000	2	1.119570
28000000	2	1.159627
29000000	2	1.202455
30000000	2	1.240473
31000000	2	1.277655
32000000	2	1.318816
33000000	2	1.360482
34000000	2	1.401964
35000000	2	1.442936
36000000	2	1.489619
37000000	2	1.529308
38000000	2	1.565938
39000000	2	1.609323
40000000	2	1.651353
41000000	2	1.690507
42000000	2	1.731546
43000000	2	1.772930
44000000	2	1.813848
45000000	2	1.854825
46000000	2	1.901210
47000000	2	1.937254
48000000	2	1.978765
49000000	2	2.020837
50000000	2	2.062308
1000000	3	0.028978
2000000	3	0.057720
3000000	3	0.086344
4000000	3	0.114919
5000000	3	0.143594
6000000	3	0.172120
7000000	3	0.200609
8000000	3	0.228878
9000000	3	0.257332
10000000	3	0.285947
11000000	3	0.314459
12000000	3	0.343128
13000000	3	0.371904
14000000	3	0.402928
15000000	3	0.429335
16000000	3	0.457816
17000000	3	0.489377
18000000	3	0.514776
19000000	3	0.543723
20000000	3	0.572181
21000000	3	0.600629
22000000	3	0.629010
23000000	3	0.661499
24000000	3	0.686398
25000000	3	0.714796
26000000	3	0.743572
27000000	3	0.771866
28000000	3	0.800096
29000000	3	0.833444
30000000	3	0.857429
31000000	3	0.886196
32000000	3	0.914557
33000000	3	0.946354
34000000	3	0.971401
35000000	3	1.000021
36000000	3	1.032035
37000000	3	1.056961
38000000	3	1.085386
39000000	3	1.113588
40000000	3	1.143650
41000000	3	1.171631
42000000	3	1.199835
43000000	3	1.227460
44000000	3	1.256195
45000000	3	1.284026
46000000	3	1.314101
47000000	3	1.346031
48000000	3	1.369909
49000000	3	1.398534
50000000	3	1.427334
1000000	4	0.022918

2000000	4	0.045476
3000000	4	0.067883
4000000	4	0.090275
5000000	4	0.112699
6000000	4	0.135065
7000000	4	0.157299
8000000	4	0.179425
9000000	4	0.201714
10000000	4	0.223992
11000000	4	0.253943
12000000	4	0.268806
13000000	4	0.291205
14000000	4	0.313760
15000000	4	0.336201
16000000	4	0.358614
17000000	4	0.380909
18000000	4	0.403176
19000000	4	0.425443
20000000	4	0.447904
21000000	4	0.470111
22000000	4	0.492343
23000000	4	0.514640
24000000	4	0.537104
25000000	4	0.559540
26000000	4	0.581739
27000000	4	0.603844
28000000	4	0.626201
29000000	4	0.648409
30000000	4	0.670854
31000000	4	0.692925
32000000	4	0.715324
33000000	4	0.737508
34000000	4	0.759977
35000000	4	0.782157
36000000	4	0.804336
37000000	4	0.826584
38000000	4	0.848830
39000000	4	0.870876
40000000	4	0.893299
41000000	4	0.915223
42000000	4	0.937600
43000000	4	0.960002
44000000	4	0.982078
45000000	4	1.004210
46000000	4	1.026627
47000000	4	1.048801
48000000	4	1.070923
49000000	4	1.093622
50000000	4	1.115302
1000000	5	0.020341
2000000	5	0.040288
3000000	5	0.060148
4000000	5	0.079939
5000000	5	0.100502
6000000	5	0.119503
7000000	5	0.139053
8000000	5	0.157943
9000000	5	0.182332
10000000	5	0.197565
11000000	5	0.214855
12000000	5	0.237302
13000000	5	0.259088
14000000	5	0.277030
15000000	5	0.297995
16000000	5	0.316766
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18000000	5	0.361046
19000000	5	0.377801
20000000	5	0.409752
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23000000	5	0.468647
24000000	5	0.473841
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26000000	5	0.519548
27000000	5	0.536884
28000000	5	0.549158
29000000	5	0.570912
30000000	5	0.591377
31000000	5	0.611650
32000000	5	0.651399
33000000	5	0.691216
34000000	5	0.677717
35000000	5	0.710989
36000000	5	0.712058
37000000	5	0.734229
38000000	5	0.748682
39000000	5	0.767957
40000000	5	0.780546
41000000	5	0.838115
42000000	5	0.853306
43000000	5	0.872695
44000000	5	0.873652
45000000	5	0.882663
46000000	5	0.904537
47000000	5	0.913986
48000000	5	0.971753
49000000	5	0.978772
50000000	5	1.016695
1000000	6	0.018626
2000000	6	0.038259
3000000	6	0.054862
4000000	6	0.072758
5000000	6	0.089007
6000000	6	0.109448
7000000	6	0.125087
8000000	6	0.142099
9000000	6	0.162416
10000000	6	0.175093
11000000	6	0.197694

12000000	6	0.214489
13000000	6	0.229218
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15000000	6	0.266003
16000000	6	0.286242
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18000000	6	0.318579
19000000	6	0.340752
20000000	6	0.357209
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23000000	6	0.419817
24000000	6	0.428665
25000000	6	0.439720
26000000	6	0.468728
27000000	6	0.474217
28000000	6	0.504895
29000000	6	0.511663
30000000	6	0.537333
31000000	6	0.547671
32000000	6	0.564315
33000000	6	0.590160
34000000	6	0.604328
35000000	6	0.630768
36000000	6	0.639858
37000000	6	0.666776
38000000	6	0.674622
39000000	6	0.700874
40000000	6	0.718579
41000000	6	0.737464
42000000	6	0.769297
43000000	6	0.757428
44000000	6	0.796119
45000000	6	0.791793
46000000	6	0.813639
47000000	6	0.843208
48000000	6	0.859745
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50000000	6	0.881940
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6000000	7	0.099274
7000000	7	0.114003
8000000	7	0.128543
9000000	7	0.148050
10000000	7	0.162511
11000000	7	0.179674
12000000	7	0.196315
13000000	7	0.214427
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20000000	7	0.327542
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25000000	7	0.403220
26000000	7	0.414333
27000000	7	0.440573
28000000	7	0.449395
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30000000	7	0.481311
31000000	7	0.505943
32000000	7	0.521293
33000000	7	0.530358
34000000	7	0.546877
35000000	7	0.563046
36000000	7	0.580276
37000000	7	0.604557
38000000	7	0.611399
39000000	7	0.627161
40000000	7	0.647601
41000000	7	0.660044
42000000	7	0.671747
43000000	7	0.699446
44000000	7	0.705594
45000000	7	0.726799
46000000	7	0.736239
47000000	7	0.755889
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3000000	8	0.044980
4000000	8	0.059739
5000000	8	0.074459
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7000000	8	0.103710
8000000	8	0.119350
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12000000	8	0.180436
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15000000	8	0.224599
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17000000	8	0.255389
18000000	8	0.269993
19000000	8	0.284578
20000000	8	0.299478
21000000	8	0.314564

22000000	8	0.324292
23000000	8	0.337513
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26000000	8	0.381057
27000000	8	0.395594
28000000	8	0.410374
29000000	8	0.424680
30000000	8	0.439136
31000000	8	0.453751
32000000	8	0.468397
33000000	8	0.482824
34000000	8	0.497244
35000000	8	0.512385
36000000	8	0.526416
37000000	8	0.549752
38000000	8	0.564929
39000000	8	0.581922
40000000	8	0.595863
41000000	8	0.610150
42000000	8	0.613959
43000000	8	0.627841
44000000	8	0.642181
45000000	8	0.656893
46000000	8	0.671108
47000000	8	0.685768
48000000	8	0.700222
49000000	8	0.714677
50000000	8	0.728963
1000000	9	0.015218
2000000	9	0.031516
3000000	9	0.045006
4000000	9	0.058871
5000000	9	0.076043
6000000	9	0.088869
7000000	9	0.112535
8000000	9	0.131297
9000000	9	0.149231
10000000	9	0.147035
11000000	9	0.162550
12000000	9	0.178547
13000000	9	0.193398
14000000	9	0.224941
15000000	9	0.232837
16000000	9	0.236897
17000000	9	0.268675
18000000	9	0.265017
19000000	9	0.276680
20000000	9	0.291200
21000000	9	0.306973
22000000	9	0.325070
23000000	9	0.339149
24000000	9	0.354785
25000000	9	0.363746
26000000	9	0.377642
27000000	9	0.393077
28000000	9	0.407382
29000000	9	0.424525
30000000	9	0.437454
31000000	9	0.448804
32000000	9	0.463653
33000000	9	0.481026
34000000	9	0.491021
35000000	9	0.512755
36000000	9	0.536333
37000000	9	0.538984
38000000	9	0.551782
39000000	9	0.561708
40000000	9	0.577922
41000000	9	0.604183
42000000	9	0.625429
43000000	9	0.624993
44000000	9	0.635489
45000000	9	0.648611
46000000	9	0.694662
47000000	9	0.680714
48000000	9	0.689932
49000000	9	0.707982
50000000	9	0.724568
1000000	10	0.017339
2000000	10	0.035557
3000000	10	0.048472
4000000	10	0.067600
5000000	10	0.079621
6000000	10	0.088875
7000000	10	0.107228
8000000	10	0.132335
9000000	10	0.132043
10000000	10	0.153765
11000000	10	0.164295
12000000	10	0.184353
13000000	10	0.196155
14000000	10	0.215501
15000000	10	0.234599
16000000	10	0.241516
17000000	10	0.257119
18000000	10	0.267635
19000000	10	0.279108
20000000	10	0.292465
21000000	10	0.307451
22000000	10	0.320705
23000000	10	0.335403
24000000	10	0.365903
25000000	10	0.367592
26000000	10	0.389012
27000000	10	0.404824
28000000	10	0.414163
29000000	10	0.427231
30000000	10	0.437997
31000000	10	0.449259

```
32000000          10          0.464982
33000000          10          0.507506
34000000          10          0.511557
35000000          10          0.516297
36000000          10          0.523548
37000000          10          0.543988
38000000          10          0.553280
39000000          10          0.565840
40000000          10          0.578813
41000000          10          0.610506
42000000          10          0.612784
43000000          10          0.629005
44000000          10          0.636195
45000000          10          0.650884
46000000          10          0.684171
47000000          10          0.683995
48000000          10          0.697809
49000000          10          0.708642
50000000          10          0.737396
```

6.3   Dynamic

Array Size — Amount of Cores — Time taken

```
1000000           1           0.116678
2000000           1           0.233901
3000000           1           0.350826
4000000           1           0.467661
5000000           1           0.584899
6000000           1           0.701356
7000000           1           0.817536
8000000           1           0.934400
9000000           1           1.051186
10000000          1           1.168617
11000000          1           1.286146
12000000          1           1.403109
13000000          1           1.519565
14000000          1           1.636986
15000000          1           1.754291
16000000          1           1.872602
17000000          1           1.988156
18000000          1           2.105850
19000000          1           2.222307
20000000          1           2.340440
21000000          1           2.455851
22000000          1           2.574008
23000000          1           2.690932
24000000          1           2.807175
25000000          1           2.923893
26000000          1           3.041565
27000000          1           3.160218
28000000          1           3.274843
29000000          1           3.393929
30000000          1           3.509836
31000000          1           3.627101
32000000          1           3.744339
33000000          1           3.860560
34000000          1           3.977942
35000000          1           4.093440
36000000          1           4.210743
37000000          1           4.327642
38000000          1           4.446550
39000000          1           4.561874
40000000          1           4.678228
41000000          1           4.793611
42000000          1           4.910355
43000000          1           5.027762
44000000          1           5.148842
45000000          1           5.264454
46000000          1           5.378911
47000000          1           5.501056
48000000          1           5.613983
49000000          1           5.729380
50000000          1           5.847780
1000000           2           0.102713
2000000           2           0.205821
3000000           2           0.308399
4000000           2           0.410918
5000000           2           0.513719
6000000           2           0.616180
7000000           2           0.719671
8000000           2           0.821295
9000000           2           0.927882
10000000          2           1.033326
11000000          2           1.129289
12000000          2           1.235403
13000000          2           1.338740
14000000          2           1.441700
15000000          2           1.546191
16000000          2           1.646558
17000000          2           1.748340
18000000          2           1.849008
19000000          2           1.954976
20000000          2           2.061965
21000000          2           2.158477
22000000          2           2.262000
23000000          2           2.367331
24000000          2           2.472800
25000000          2           2.574271
26000000          2           2.672324
27000000          2           2.778947
28000000          2           2.879263
29000000          2           2.986923
30000000          2           3.088449
31000000          2           3.188176
```

32000000	2	3.289348
33000000	2	3.391261
34000000	2	3.494538
35000000	2	3.606683
36000000	2	3.700820
37000000	2	3.804951
38000000	2	3.907827
39000000	2	4.009485
40000000	2	4.112471
41000000	2	4.224700
42000000	2	4.320244
43000000	2	4.438818
44000000	2	4.533182
45000000	2	4.633481
46000000	2	4.735178
47000000	2	4.831608
48000000	2	4.934141
49000000	2	5.080143
50000000	2	5.192479
1000000	3	0.087589
2000000	3	0.174541
3000000	3	0.262160
4000000	3	0.349956
5000000	3	0.435859
6000000	3	0.524675
7000000	3	0.610195
8000000	3	0.697400
9000000	3	0.784032
10000000	3	0.870276
11000000	3	0.958541
12000000	3	1.045692
13000000	3	1.132414
14000000	3	1.219881
15000000	3	1.307890
16000000	3	1.394084
17000000	3	1.482020
18000000	3	1.569297
19000000	3	1.656486
20000000	3	1.742569
21000000	3	1.829891
22000000	3	1.917170
23000000	3	2.005027
24000000	3	2.091587
25000000	3	2.178802
26000000	3	2.265680
27000000	3	2.352863
28000000	3	2.449105
29000000	3	2.527551
30000000	3	2.618825
31000000	3	2.701560
32000000	3	2.789728
33000000	3	2.876650
34000000	3	2.963425
35000000	3	3.061608
36000000	3	3.137412
37000000	3	3.224754
38000000	3	3.317404
39000000	3	3.408574
40000000	3	3.486225
41000000	3	3.574654
42000000	3	3.668315
43000000	3	3.748396
44000000	3	3.834489
45000000	3	3.923646
46000000	3	4.015065
47000000	3	4.096302
48000000	3	4.185997
49000000	3	4.271439
50000000	3	4.357497
1000000	4	0.080282
2000000	4	0.160887
3000000	4	0.240874
4000000	4	0.321080
5000000	4	0.401407
6000000	4	0.481488
7000000	4	0.561598
8000000	4	0.641605
9000000	4	0.721687
10000000	4	0.801893
11000000	4	0.882024
12000000	4	0.962200
13000000	4	1.042532
14000000	4	1.114909
15000000	4	1.202914
16000000	4	1.282965
17000000	4	1.363190
18000000	4	1.443376
19000000	4	1.523504
20000000	4	1.603813
21000000	4	1.683837
22000000	4	1.764122
23000000	4	1.844198
24000000	4	1.924289
25000000	4	2.004413
26000000	4	2.084559
27000000	4	2.164998
28000000	4	2.245016
29000000	4	2.325093
30000000	4	2.405383
31000000	4	2.485383
32000000	4	2.563476
33000000	4	2.645886
34000000	4	2.725946
35000000	4	2.806210
36000000	4	2.886279
37000000	4	2.966384
38000000	4	3.046530
39000000	4	3.126701
40000000	4	3.206993
41000000	4	3.286952

42000000	4	3.367620
43000000	4	3.447427
44000000	4	3.527439
45000000	4	3.607793
46000000	4	3.687600
47000000	4	3.767693
48000000	4	3.846870
49000000	4	3.927986
50000000	4	4.008254
1000000	5	0.073196
2000000	5	0.146444
3000000	5	0.219395
4000000	5	0.292495
5000000	5	0.365632
6000000	5	0.438559
7000000	5	0.511349
8000000	5	0.584271
9000000	5	0.656833
10000000	5	0.730217
11000000	5	0.803295
12000000	5	0.876139
13000000	5	0.949368
14000000	5	1.023520
15000000	5	1.095484
16000000	5	1.168260
17000000	5	1.241190
18000000	5	1.314164
19000000	5	1.387140
20000000	5	1.460150
21000000	5	1.533275
22000000	5	1.606075
23000000	5	1.679183
24000000	5	1.752186
25000000	5	1.825115
26000000	5	1.898101
27000000	5	1.970995
28000000	5	2.045292
29000000	5	2.117481
30000000	5	2.189965
31000000	5	2.292480
32000000	5	2.374318
33000000	5	2.448054
34000000	5	2.484626
35000000	5	2.556525
36000000	5	2.632893
37000000	5	2.706097
38000000	5	2.777135
39000000	5	2.852422
40000000	5	2.925805
41000000	5	3.000887
42000000	5	3.074014
43000000	5	3.151174
44000000	5	3.218826
45000000	5	3.291087
46000000	5	3.363380
47000000	5	3.436757
48000000	5	3.509773
49000000	5	3.582839
50000000	5	3.656081
1000000	6	0.069764
2000000	6	0.140063
3000000	6	0.209583
4000000	6	0.279374
5000000	6	0.349278
6000000	6	0.418896
7000000	6	0.488542
8000000	6	0.558239
9000000	6	0.627764
10000000	6	0.697366
11000000	6	0.766768
12000000	6	0.836600
13000000	6	0.906163
14000000	6	0.982197
15000000	6	1.050569
16000000	6	1.117797
17000000	6	1.187459
18000000	6	1.250730
19000000	6	1.330009
20000000	6	1.397486
21000000	6	1.467151
22000000	6	1.542693
23000000	6	1.600399
24000000	6	1.669342
25000000	6	1.750647
26000000	6	1.820700
27000000	6	1.875426
28000000	6	1.956633
29000000	6	2.017659
30000000	6	2.089547
31000000	6	2.156141
32000000	6	2.233151
33000000	6	2.297635
34000000	6	2.364140
35000000	6	2.433333
36000000	6	2.512779
37000000	6	2.579190
38000000	6	2.648809
39000000	6	2.720529
40000000	6	2.782419
41000000	6	2.859721
42000000	6	2.951737
43000000	6	2.998767
44000000	6	3.074376
45000000	6	3.143491
46000000	6	3.213346
47000000	6	3.283138
48000000	6	3.354312
49000000	6	3.422701
50000000	6	3.492575
1000000	7	0.069285

2000000	7	0.139065
3000000	7	0.208014
4000000	7	0.276370
5000000	7	0.343691
6000000	7	0.415491
7000000	7	0.484474
8000000	7	0.551102
9000000	7	0.617999
10000000	7	0.710905
11000000	7	0.756313
12000000	7	0.824781
13000000	7	0.888951
14000000	7	0.962599
15000000	7	1.023252
16000000	7	1.098863
17000000	7	1.161352
18000000	7	1.231268
19000000	7	1.297708
20000000	7	1.367367
21000000	7	1.436994
22000000	7	1.504140
23000000	7	1.572347
24000000	7	1.637235
25000000	7	1.708439
26000000	7	1.777365
27000000	7	1.842201
28000000	7	1.916946
29000000	7	1.979479
30000000	7	2.063290
31000000	7	2.121550
32000000	7	2.189808
33000000	7	2.250094
34000000	7	2.333203
35000000	7	2.397619
36000000	7	2.465383
37000000	7	2.535019
38000000	7	2.611311
39000000	7	2.671005
40000000	7	2.735170
41000000	7	2.808399
42000000	7	2.890607
43000000	7	2.930185
44000000	7	3.010251
45000000	7	3.070669
46000000	7	3.152598
47000000	7	3.224810
48000000	7	3.272037
49000000	7	3.366211
50000000	7	3.414728
1000000	8	0.066715
2000000	8	0.133999
3000000	8	0.200302
4000000	8	0.268197
5000000	8	0.335384
6000000	8	0.402128
7000000	8	0.468897
8000000	8	0.535483
9000000	8	0.602324
10000000	8	0.669303
11000000	8	0.732351
12000000	8	0.798903
13000000	8	0.865489
14000000	8	0.932726
15000000	8	0.998273
16000000	8	1.064645
17000000	8	1.131154
18000000	8	1.203763
19000000	8	1.270127
20000000	8	1.330322
21000000	8	1.396705
22000000	8	1.463478
23000000	8	1.529467
24000000	8	1.595947
25000000	8	1.670340
26000000	8	1.730373
27000000	8	1.795077
28000000	8	1.862839
29000000	8	1.935632
30000000	8	2.004216
31000000	8	2.061488
32000000	8	2.127456
33000000	8	2.194016
34000000	8	2.263402
35000000	8	2.329409
36000000	8	2.393294
37000000	8	2.459657
38000000	8	2.528695
39000000	8	2.592301
40000000	8	2.658513
41000000	8	2.725573
42000000	8	2.808212
43000000	8	2.857634
44000000	8	2.924734
45000000	8	2.991255
46000000	8	3.058035
47000000	8	3.123151
48000000	8	3.192748
49000000	8	3.255834
50000000	8	3.321583
1000000	9	0.073066
2000000	9	0.146790
3000000	9	0.219159
4000000	9	0.292169
5000000	9	0.377337
6000000	9	0.437818
7000000	9	0.510766
8000000	9	0.583106
9000000	9	0.655995
10000000	9	0.728295
11000000	9	0.801517

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12000000        9       0.873753
13000000        9       0.946885
14000000        9       1.020538
15000000        9       1.092518
16000000        9       1.164682
17000000        9       1.237685
18000000        9       1.310048
19000000        9       1.383032
20000000        9       1.455840
21000000        9       1.528240
22000000        9       1.601206
23000000        9       1.673460
24000000        9       1.746921
25000000        9       1.818736
26000000        9       1.891265
27000000        9       1.963999
28000000        9       2.044094
29000000        9       2.109413
30000000        9       2.182068
31000000        9       2.254665
32000000        9       2.327105
33000000        9       2.399827
34000000        9       2.472719
35000000        9       2.544832
36000000        9       2.617538
37000000        9       2.690635
38000000        9       2.762723
39000000        9       2.835641
40000000        9       2.908085
41000000        9       2.981275
42000000        9       3.056644
43000000        9       3.126539
44000000        9       3.198630
45000000        9       3.270586
46000000        9       3.343170
47000000        9       3.417567
48000000        9       3.489170
49000000        9       3.582072
50000000        9       3.661504
1000000         10      0.067780
2000000         10      0.136390
3000000         10      0.203599
4000000         10      0.271193
5000000         10      0.338988
6000000         10      0.416477
7000000         10      0.474066
8000000         10      0.541673
9000000         10      0.609137
10000000        10      0.673957
11000000        10      0.743706
12000000        10      0.811710
13000000        10      0.879282
14000000        10      0.941909
15000000        10      1.019907
16000000        10      1.085902
17000000        10      1.149783
18000000        10      1.216497
19000000        10      1.284368
20000000        10      1.351295
21000000        10      1.432343
22000000        10      1.486437
23000000        10      1.552000
24000000        10      1.621226
25000000        10      1.689423
26000000        10      1.755821
27000000        10      1.823583
28000000        10      1.893124
29000000        10      1.968244
30000000        10      2.025464
31000000        10      2.093688
32000000        10      2.159947
33000000        10      2.239849
34000000        10      2.295102
35000000        10      2.362590
36000000        10      2.429873
37000000        10      2.497677
38000000        10      2.565077
39000000        10      2.636836
40000000        10      2.699613
41000000        10      2.774470
42000000        10      2.836585
43000000        10      2.899546
44000000        10      2.969524
45000000        10      3.036971
46000000        10      3.103944
47000000        10      3.191376
48000000        10      3.237716
49000000        10      3.306063
50000000        10      3.372898
```

6.4   Static

Array Size — Amount of Cores — Time taken

```
1000000         1       0.080914
2000000         1       0.157724
3000000         1       0.236725
4000000         1       0.315702
5000000         1       0.394773
6000000         1       0.472902
7000000         1       0.551556
8000000         1       0.630534
9000000         1       0.709008
10000000        1       0.788208
11000000        1       0.867400
```

12000000	1	0.947243
13000000	1	1.025953
14000000	1	1.104308
15000000	1	1.183911
16000000	1	1.263313
17000000	1	1.342357
18000000	1	1.422051
19000000	1	1.500518
20000000	1	1.578356
21000000	1	1.657893
22000000	1	1.735847
23000000	1	1.815458
24000000	1	1.895681
25000000	1	1.973574
26000000	1	2.052083
27000000	1	2.131019
28000000	1	2.210884
29000000	1	2.289442
30000000	1	2.368570
31000000	1	2.446854
32000000	1	2.525521
33000000	1	2.606644
34000000	1	2.683255
35000000	1	2.762026
36000000	1	2.841479
37000000	1	2.922394
38000000	1	3.000474
39000000	1	3.078202
40000000	1	3.158714
41000000	1	3.236315
42000000	1	3.314069
43000000	1	3.394317
44000000	1	3.471126
45000000	1	3.554718
46000000	1	3.628974
47000000	1	3.709532
48000000	1	3.790600
49000000	1	3.867604
50000000	1	3.944752
1000000	2	0.041134
2000000	2	0.082441
3000000	2	0.123529
4000000	2	0.164641
5000000	2	0.205831
6000000	2	0.246592
7000000	2	0.287179
8000000	2	0.328092
9000000	2	0.369018
10000000	2	0.412675
11000000	2	0.451666
12000000	2	0.492971
13000000	2	0.535624
14000000	2	0.576777
15000000	2	0.617973
16000000	2	0.659129
17000000	2	0.702391
18000000	2	0.741008
19000000	2	0.786488
20000000	2	0.823072
21000000	2	0.864179
22000000	2	0.906236
23000000	2	0.945783
24000000	2	0.986662
25000000	2	1.033389
26000000	2	1.069865
27000000	2	1.110491
28000000	2	1.154781
29000000	2	1.192078
30000000	2	1.237710
31000000	2	1.275489
32000000	2	1.314171
33000000	2	1.355920
34000000	2	1.396761
35000000	2	1.437178
36000000	2	1.486588
37000000	2	1.526620
38000000	2	1.561085
39000000	2	1.600930
40000000	2	1.642754
41000000	2	1.683836
42000000	2	1.723798
43000000	2	1.766671
44000000	2	1.809173
45000000	2	1.852361
46000000	2	1.898513
47000000	2	1.933777
48000000	2	1.972238
49000000	2	2.018154
50000000	2	2.057075
1000000	3	0.029000
2000000	3	0.057807
3000000	3	0.086009
4000000	3	0.114527
5000000	3	0.143006
6000000	3	0.171254
7000000	3	0.199555
8000000	3	0.227820
9000000	3	0.256224
10000000	3	0.285040
11000000	3	0.313900
12000000	3	0.342908
13000000	3	0.371499
14000000	3	0.400066
15000000	3	0.428397
16000000	3	0.456761
17000000	3	0.485127
18000000	3	0.513651
19000000	3	0.542101
20000000	3	0.570488
21000000	3	0.599932

22000000	3	0.627392
23000000	3	0.655610
24000000	3	0.684307
25000000	3	0.713004
26000000	3	0.741120
27000000	3	0.769664
28000000	3	0.797837
29000000	3	0.826414
30000000	3	0.854608
31000000	3	0.882699
32000000	3	0.911671
33000000	3	0.941120
34000000	3	0.968274
35000000	3	0.996185
36000000	3	1.025417
37000000	3	1.053284
38000000	3	1.081791
39000000	3	1.109250
40000000	3	1.141857
41000000	3	1.166688
42000000	3	1.195023
43000000	3	1.222608
44000000	3	1.251895
45000000	3	1.280008
46000000	3	1.310309
47000000	3	1.336191
48000000	3	1.366553
49000000	3	1.393401
50000000	3	1.425307
1000000	4	0.022827
2000000	4	0.045292
3000000	4	0.067612
4000000	4	0.089928
5000000	4	0.112324
6000000	4	0.134291
7000000	4	0.156496
8000000	4	0.178536
9000000	4	0.200994
10000000	4	0.223640
11000000	4	0.246383
12000000	4	0.268715
13000000	4	0.291025
14000000	4	0.313311
15000000	4	0.335561
16000000	4	0.357748
17000000	4	0.379949
18000000	4	0.402186
19000000	4	0.424543
20000000	4	0.446636
21000000	4	0.468886
22000000	4	0.490961
23000000	4	0.513219
24000000	4	0.535337
25000000	4	0.557591
26000000	4	0.579598
27000000	4	0.601794
28000000	4	0.624051
29000000	4	0.646153
30000000	4	0.668168
31000000	4	0.690343
32000000	4	0.712778
33000000	4	0.734843
34000000	4	0.757260
35000000	4	0.779078
36000000	4	0.801459
37000000	4	0.823636
38000000	4	0.845920
39000000	4	0.868519
40000000	4	0.890100
41000000	4	0.912318
42000000	4	0.934392
43000000	4	0.956501
44000000	4	0.978448
45000000	4	1.000896
46000000	4	1.022901
47000000	4	1.044976
48000000	4	1.067299
49000000	4	1.088993
50000000	4	1.111350
1000000	5	0.022865
2000000	5	0.045345
3000000	5	0.067233
4000000	5	0.089572
5000000	5	0.111828
6000000	5	0.133827
7000000	5	0.155915
8000000	5	0.177947
9000000	5	0.200182
10000000	5	0.222505
11000000	5	0.244687
12000000	5	0.267039
13000000	5	0.289167
14000000	5	0.311263
15000000	5	0.333573
16000000	5	0.355853
17000000	5	0.378122
18000000	5	0.400335
19000000	5	0.422765
20000000	5	0.444823
21000000	5	0.467045
22000000	5	0.489183
23000000	5	0.512778
24000000	5	0.533506
25000000	5	0.553489
26000000	5	0.578517
27000000	5	0.600486
28000000	5	0.622548
29000000	5	0.644790
30000000	5	0.666903
31000000	5	0.688738

32000000	5	0.711236
33000000	5	0.733375
34000000	5	0.755118
35000000	5	0.777237
36000000	5	0.798996
37000000	5	0.821625
38000000	5	0.843392
39000000	5	0.865662
40000000	5	0.887694
41000000	5	0.907178
42000000	5	0.918675
43000000	5	0.950101
44000000	5	0.927050
45000000	5	0.995349
46000000	5	0.991372
47000000	5	1.038075
48000000	5	1.048004
49000000	5	1.083356
50000000	5	1.073463
1000000	6	0.019544
2000000	6	0.038680
3000000	6	0.057612
4000000	6	0.076455
5000000	6	0.095657
6000000	6	0.114386
7000000	6	0.132997
8000000	6	0.151955
9000000	6	0.170605
10000000	6	0.189403
11000000	6	0.208699
12000000	6	0.225356
13000000	6	0.244169
14000000	6	0.262964
15000000	6	0.281127
16000000	6	0.300382
17000000	6	0.321946
18000000	6	0.341061
19000000	6	0.360182
20000000	6	0.374155
21000000	6	0.397175
22000000	6	0.416790
23000000	6	0.433841
24000000	6	0.454843
25000000	6	0.473645
26000000	6	0.492246
27000000	6	0.510075
28000000	6	0.528186
29000000	6	0.542512
30000000	6	0.561314
31000000	6	0.579669
32000000	6	0.605124
33000000	6	0.616790
34000000	6	0.634667
35000000	6	0.654375
36000000	6	0.672410
37000000	6	0.691765
38000000	6	0.715726
39000000	6	0.734973
40000000	6	0.755656
41000000	6	0.773043
42000000	6	0.791567
43000000	6	0.810764
44000000	6	0.829423
45000000	6	0.848028
46000000	6	0.866796
47000000	6	0.885543
48000000	6	0.904202
49000000	6	0.922351
50000000	6	0.941469
1000000	7	0.017097
2000000	7	0.033746
3000000	7	0.050278
4000000	7	0.066734
5000000	7	0.083255
6000000	7	0.099664
7000000	7	0.115949
8000000	7	0.132161
9000000	7	0.148625
10000000	7	0.165357
11000000	7	0.181602
12000000	7	0.198068
13000000	7	0.214580
14000000	7	0.231000
15000000	7	0.247660
16000000	7	0.263998
17000000	7	0.280877
18000000	7	0.296283
19000000	7	0.312655
20000000	7	0.329029
21000000	7	0.345258
22000000	7	0.361788
23000000	7	0.378536
24000000	7	0.394284
25000000	7	0.420074
26000000	7	0.422112
27000000	7	0.438420
28000000	7	0.454820
29000000	7	0.470429
30000000	7	0.486596
31000000	7	0.502672
32000000	7	0.526322
33000000	7	0.535037
34000000	7	0.550858
35000000	7	0.574485
36000000	7	0.591416
37000000	7	0.599724
38000000	7	0.615514
39000000	7	0.639122
40000000	7	0.647619
41000000	7	0.672541

42000000	7	0.688963
43000000	7	0.704568
44000000	7	0.721311
45000000	7	0.737589
46000000	7	0.743412
47000000	7	0.793128
48000000	7	0.775977
49000000	7	0.802629
50000000	7	0.818430
1000000	8	0.015310
2000000	8	0.030162
3000000	8	0.044851
4000000	8	0.059595
5000000	8	0.074347
6000000	8	0.088862
7000000	8	0.103362
8000000	8	0.117833
9000000	8	0.132421
10000000	8	0.147172
11000000	8	0.161763
12000000	8	0.176431
13000000	8	0.191387
14000000	8	0.206052
15000000	8	0.220642
16000000	8	0.235180
17000000	8	0.249734
18000000	8	0.264318
19000000	8	0.278870
20000000	8	0.293453
21000000	8	0.308125
22000000	8	0.322583
23000000	8	0.366018
24000000	8	0.382597
25000000	8	0.398123
26000000	8	0.414456
27000000	8	0.430076
28000000	8	0.446137
29000000	8	0.461969
30000000	8	0.438842
31000000	8	0.452906
32000000	8	0.467474
33000000	8	0.482067
34000000	8	0.496572
35000000	8	0.510945
36000000	8	0.525502
37000000	8	0.539937
38000000	8	0.554751
39000000	8	0.568924
40000000	8	0.583345
41000000	8	0.597894
42000000	8	0.612500
43000000	8	0.682359
44000000	8	0.698070
45000000	8	0.713841
46000000	8	0.722579
47000000	8	0.684416
48000000	8	0.698750
49000000	8	0.713549
50000000	8	0.727683
1000000	9	0.022243
2000000	9	0.037509
3000000	9	0.052056
4000000	9	0.072685
5000000	9	0.092995
6000000	9	0.108164
7000000	9	0.125869
8000000	9	0.144019
9000000	9	0.159130
10000000	9	0.175896
11000000	9	0.195456
12000000	9	0.212673
13000000	9	0.231274
14000000	9	0.246664
15000000	9	0.264547
16000000	9	0.280486
17000000	9	0.297838
18000000	9	0.298364
19000000	9	0.335167
20000000	9	0.346469
21000000	9	0.368943
22000000	9	0.367873
23000000	9	0.373660
24000000	9	0.411085
25000000	9	0.411753
26000000	9	0.419339
27000000	9	0.452501
28000000	9	0.484945
29000000	9	0.452119
30000000	9	0.481645
31000000	9	0.525930
32000000	9	0.517528
33000000	9	0.558111
34000000	9	0.585737
35000000	9	0.596244
36000000	9	0.576051
37000000	9	0.595947
38000000	9	0.623275
39000000	9	0.630423
40000000	9	0.653069
41000000	9	0.656156
42000000	9	0.680512
43000000	9	0.716904
44000000	9	0.706012
45000000	9	0.747799
46000000	9	0.769121
47000000	9	0.752134
48000000	9	0.753496
49000000	9	0.836780
50000000	9	0.819243
1000000	10	0.020370

2000000	10	0.035659
3000000	10	0.052626
4000000	10	0.068621
5000000	10	0.086449
6000000	10	0.105020
7000000	10	0.134073
8000000	10	0.135148
9000000	10	0.151409
10000000	10	0.165400
11000000	10	0.184519
12000000	10	0.198077
13000000	10	0.220321
14000000	10	0.225852
15000000	10	0.252346
16000000	10	0.262221
17000000	10	0.282217
18000000	10	0.294145
19000000	10	0.309511
20000000	10	0.320529
21000000	10	0.343711
22000000	10	0.356127
23000000	10	0.379654
24000000	10	0.398082
25000000	10	0.411067
26000000	10	0.428080
27000000	10	0.442286
28000000	10	0.477383
29000000	10	0.480713
30000000	10	0.495268
31000000	10	0.510340
32000000	10	0.508283
33000000	10	0.537794
34000000	10	0.557842
35000000	10	0.558705
36000000	10	0.587461
37000000	10	0.602027
38000000	10	0.603581
39000000	10	0.635860
40000000	10	0.655595
41000000	10	0.663305
42000000	10	0.660883
43000000	10	0.670623
44000000	10	0.696467
45000000	10	0.702193
46000000	10	0.741874
47000000	10	0.741291
48000000	10	0.792577
49000000	10	0.781222
50000000	10	0.784744

6.5   MPI ScatterV

#Run	1 Process			2 Process's			3 Process's			4 Process's		
	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values
1	0.02640199661	0.01466584206	0.01173615456	0.02151298523	0.01364088058	0.007872104645	0.02384996414	0.0152451992	0.008604764938	0.02123713493	0.01446557045	0.006771564484
2	0.02626109123	0.01450014114	0.01176095009	0.02155303955	0.01366996765	0.007883071899	0.02170109749	0.015843153	0.005857944489	0.02039384842	0.01532292366	0.005070924759
3	0.02635407448	0.01453995705	0.01181411743	0.02151203156	0.01365423203	0.00785779953	0.02369809151	0.0151052475	0.008592844009	0.02253103256	0.01574587822	0.006785154343
4	0.02855014801	0.01672101021	0.0118291378	0.02151703835	0.01364994049	0.007867097855	0.02375483513	0.01504087448	0.008713960648	0.02291512489	0.01606726646	0.006847858429
5	0.02647805214	0.01454591751	0.01193213463	0.02140402794	0.013641119	0.007762908936	0.02152395248	0.01566267014	0.005861282349	0.02296590805	0.01608800888	0.00687789917
6	0.02641510963	0.01458835602	0.0118267536	0.02153897285	0.01371479034	0.00782418251	0.02149200439	0.01563405991	0.005857944489	0.02266788483	0.01590800285	0.006759881973
7	0.02623105049	0.01442909241	0.0118019580	0.02150893211	0.0136449337	0.00786399841	0.02384614944	0.01524376869	0.008602380753	0.02246212959	0.01569890976	0.006763219833
8	0.02645516396	0.01436686516	0.0120882988	0.02147102356	0.01361823082	0.00785279274	0.02389788628	0.01530337334	0.008594512939	0.02063393593	0.01558089256	0.005053043365
9	0.02606487274	0.01430916786	0.01175570488	0.0214869976	0.01366496086	0.007822036743	0.02163696289	0.01575374603	0.005883216858	0.02190208435	0.01691222191	0.004989862442
10	0.02636790276	0.01456212997	0.01180577278	0.02142715454	0.01371479034	0.007712364197	0.0214881897	0.01540803909	0.006080150604	0.0205180645	0.015440403	0.0050740242
11	0.02642011642	0.01465392113	0.0117661953	0.02151083946	0.01365399361	0.007856845856	0.02144408226	0.01551032066	0.005933761597	0.02252602577	0.01527810097	0.007247924805
12	0.02627491951	0.01442313873	0.01184678078	0.0262248516	0.01844620705	0.007778644562	0.02384018898	0.01521682739	0.008623361588	0.02304506302	0.01604604721	0.006999015808
13	0.02618098259	0.0144598484	0.01172113419	0.02147388458	0.01365184784	0.007822036743	0.0237741062	0.01502013206	0.008723974228	0.02209687233	0.01710891724	0.004987955093
14	0.02677106857	0.01471304893	0.0120580194	0.02153682709	0.01369404793	0.0084277916	0.02166008949	0.01578593254	0.005874156952	0.02344799042	0.01608991623	0.007358074188
15	0.02625489235	0.0144033432	0.01185154915	0.02151203156	0.0136680603	0.00784397252	0.02132105827	0.01543164253	0.005889415741	0.02212190628	0.01713418961	0.004987716675
16	0.02631187439	0.01446986198	0.0118420124	0.0216171745	0.0136672923	0.007947444916	0.02162694931	0.01576399803	0.005862951279	0.02273917198	0.0160009861	0.006738185883
17	0.0262761116	0.01445603371	0.0118200779	0.02133798599	0.01361489296	0.007723093033	0.02154898643	0.01568484306	0.005864143372	0.02126097679	0.01459884644	0.006662130356
18	0.02669501305	0.01461100578	0.0120840726	0.02132487297	0.01358580589	0.007739067078	0.02151107788	0.01562714577	0.005883932114	0.02245402336	0.01534080505	0.007113218307
19	0.02613997459	0.01434707642	0.0117928981	0.0214679241	0.01373577118	0.007732152939	0.02127504349	0.01540803909	0.005867004395	0.02292203903	0.0160586834	0.006863355637
20	0.02614212036	0.01429867744	0.01184344292	0.02133011818	0.01361322403	0.00771689415	0.02126002312	0.01539587975	0.005864143372	0.02285814285	0.01604008675	0.006810581506
21	0.02622008324	0.01443910599	0.0117809725	0.02152013779	0.01365804672	0.007862091064	0.02340292931	0.01541590691	0.0079870224	0.02242612839	0.0152759552	0.007150173187
22	0.026252985	0.01443719864	0.01181578636	0.02144193649	0.01370573044	0.00773620605	0.02375197411	0.01515698433	0.008594989777	0.02304911613	0.01623988152	0.006809234619
23	0.02655291557	0.01464176178	0.01191115379	0.0216190815	0.01373910904	0.00787997245	0.02382588387	0.01525020599	0.008575677872	0.02278804779	0.01599287987	0.006795167923
Min	0.02606487274	0.01429867744	0.01172113419	0.02132487297	0.01358580589	0.007712364197	0.02126002312	0.01502013206	0.005857944489	0.02291703224	0.01607179642	0.00498716675
Avg	0.02855014801	0.01672101021	0.0120882988	0.0262248516	0.01844620705	0.007947444916	0.02389788628	0.015843153	0.008723974228	0.02243089676	0.0151860714	0.007358074188
Max	0.02643793562	0.01459076094	0.01184717469	0.02168912473	0.0138717527	0.007817372032	0.02248267505	0.01543078215	0.007051892903	0.02248191833	0.01530003548	0.006414071373

	5 Process			6 Process's			7 Process's			8 Process's		
#Run	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values
1	0.04358386993	0.03755187988	0.006031990051	0.02115392685	0.01571583748	0.005438089371	0.02711892128	0.02142715454	0.005691766739	0.06187796593	0.05725002289	0.004627943039
2	0.02268600464	0.01653242111	0.006153583527	0.02109098434	0.01566910744	0.005421876907	0.03754281998	0.03232312202	0.005219697952	0.04545021057	0.04023790359	0.005212306976
3	0.03569293022	0.02978682518	0.005906105042	0.0212199688	0.01658179425	0.005532026291	0.03143596649	0.02611303329	0.005322933197	0.05311203003	0.04787898064	0.005233049393
4	0.02160596848	0.01524782181	0.006358146667	0.02136087418	0.01611924171	0.005241632462	0.03557395935	0.03030323982	0.005270719528	0.3786489964	0.3632779121	0.01537108421
5	0.02175188065	0.01527404785	0.006477832794	0.02109599113	0.01559591293	0.005500078201	0.03585386276	0.0304787159	0.005375146866	0.05378603935	0.04865717888	0.005128860474
6	0.02162098885	0.01524090767	0.006380081177	0.02136898041	0.01608014107	0.0028883934	0.08446002007	0.07917380333	0.005286216736	0.08448600769	0.07950520515	0.004980802536
7	0.02174592018	0.01570606232	0.006039857864	0.0211379528	0.01570463181	0.005433320999	0.03586506844	0.0305082798	0.005356788635	0.03927993774	0.03436613083	0.004913806915
8	0.02243900299	0.01595473289	0.006484270096	0.02108216286	0.01552700996	0.005555152893	0.03955483437	0.03444194794	0.005112886429	0.03596401215	0.03089189529	0.005072116852
9	0.0211930275	0.01652598381	0.004667043686	0.02104711533	0.01554107666	0.005506038666	0.0918469429	0.08655714989	0.005289793015	0.12641716	0.1215791702	0.004837989807
10	0.02121305466	0.01651620865	0.004696846008	0.02127599716	0.01579999924	0.005475997925	0.04592180252	0.04098677635	0.004935026169	0.106623888	0.1015648842	0.00505900383
11	0.0216281414	0.01561522484	0.006012916565	0.02176594734	0.01577305794	0.005992889404	0.03045487404	0.02535700798	0.005097866058	0.03472995758	0.0298538208	0.00487613678
12	0.02242588997	0.0158367157	0.006589174271	0.02150702477	0.01559329033	0.005913734436	0.08964800835	0.08436155319	0.005286455154	0.04290485382	0.03824710846	0.004657745361
13	0.03181695938	0.02733016014	0.00448679924	0.1295120716	0.1239469051	0.005565166473	0.04869580269	0.04370141029	0.004994392395	0.05166006088	0.04670095444	0.004959106445
14	0.02170610428	0.01535511017	0.00635099411	0.02187609673	0.01615166664	0.005724430084	0.04360413551	0.03855204582	0.005052089691	0.03291296959	0.02787995338	0.005033016205
15	0.02148318291	0.01508879662	0.006394386292	0.02173304558	0.01581788603	0.005915164948	0.02799105644	0.02271008492	0.005280971527	0.1506619453	0.1457650661	0.004896879196
16	0.0215408802	0.01512694359	0.006413936615	0.0217859745	0.01579904556	0.00598692894	0.04127502441	0.03545880318	0.005816221237	0.2075920105	0.2027311325	0.004860877991
17	0.0223338604	0.01585221291	0.006481647491	0.02163791656	0.01572561264	0.005912303925	0.04658198357	0.04132914543	0.005252838135	0.03577494621	0.03063583374	0.005139112473
18	0.02232694626	0.01585483551	0.006472110748	0.03023910522	0.0261387825	0.004100322723	0.0424349308	0.03667926788	0.005755662918	0.02885603905	0.0238969326	0.004959106445
19	0.02248811722	0.01592588425	0.00656223971	0.0217320919	0.01574516296	0.00598692894	0.04722189903	0.04183506966	0.005386829376	0.03520488739	0.02943992615	0.005764961243
20	0.03272509575	0.02293992043	0.009785175323	0.02168488503	0.01563644409	0.006048440933	0.3996288776	0.3944003582	0.00522851944	0.03608989716	0.03090786934	0.005182027817
21	0.02164196968	0.01575016975	0.005891799927	0.02171516418	0.01572084427	0.005994319916	0.03832888603	0.03299212456	0.005336761475	0.03802800179	0.03271698952	0.005311012268
22	0.03924107552	0.03327488899	0.005966186523	0.02195811272	0.01625108719	0.005707025528	0.03371691704	0.02843284607	0.005284070969	0.05384802818	0.04899430275	0.004853725433
23	0.02612996101	0.01748991013	0.008640050888	0.02164196968	0.01572108269	0.005920886993	0.04216694832	0.03693890572	0.005228042603	0.09683990479	0.09198403358	0.004855871201
Min	0.0211930275	0.01508879662	0.00448679924	0.02173686028	0.01568508148	0.004100322723	0.02711892128	0.02142715454	0.004935026169	0.02885603905	0.0238969326	0.004627943039
Avg	0.04358386993	0.03755187988	0.009785175323	0.1295120716	0.1239469051	0.006048440933	0.3996288776	0.3944003582	0.005816221237	0.3786489964	0.3632779121	0.01537108421
Max	0.02526177531	0.01894685496	0.006314920342	0.02654884173	0.02093312015	0.005615721578	0.06073580617	0.05543747156	0.005298334619	0.07959781522	0.0741288351	0.005468980126

	9 Process			10 Process's			15 Process's			20 Process's		
#Run	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values	Overall time taken	Time taken to synchronize	Time taken to compute values
1	0.2018561363	0.1972072124	0.004648923874	0.06706404686	0.06230688095	0.004757165909	0.2812080383	0.2668330669	0.01437497139	0.4191868305	0.4157910347	0.003395795822
2	0.214591992	0.2104158401	0.004536151886	0.0483880043	0.04378390312	0.004604101181	0.07885503769	0.07544493675	0.003410100937	0.3099229336	0.3065698147	0.003353118896
3	0.05425691605	0.04965591431	0.00460100174	0.08414506912	0.06957888603	0.01456618309	0.3243019581	0.3209691048	0.003332853317	0.4212539196	0.4178769588	0.003376960754
4	0.3359630108	0.3309881687	0.004974842072	0.06176686287	0.05737400055	0.00439286232	0.2822859287	0.2787210941	0.003564834595	0.4681220055	0.4647741318	0.003347873688
5	0.1129368736	0.1079368591	0.005000114441	0.1499090195	0.1455571651	0.004351854324	0.3419809341	0.3382749557	0.003705978394	0.4494380951	0.4460849762	0.003353118896
6	0.0892829895	0.08475708961	0.004525899887	0.04830598831	0.04370498657	0.00460100174	0.1987659931	0.1840832233	0.01468276978	0.5217750072	0.5183858871	0.003389120102
7	0.2530958652	0.2482788563	0.004817008972	0.1552481651	0.1508889198	0.0043592453	0.2624928951	0.2482168674	0.01427602768	0.4531888962	0.449760437	0.003428459167
8	0.03596305847	0.0309741497	0.004988908768	0.05437207222	0.04975390434	0.004618167877	0.3221480846	0.3182780743	0.003870010376	0.5490760803	0.5350980759	0.01397800446
9	0.1412580013	0.1364569664	0.00480103927	0.1376681328	0.1332292557	0.00443877106	0.1567158699	0.1529791355	0.00373673439	0.3441450596	0.3407518864	0.003393173218
10	0.05308294296	0.04818034172	0.004902601242	0.05102705956	0.04649567604	0.004531383514	0.2728588581	0.2690370083	0.003821849823	0.3782758713	0.374894619	0.003381252289
11	0.06465101242	0.06003308296	0.004617929459	0.08987402916	0.08545398712	0.00442004038	0.3138229847	0.3101520538	0.003670930862	0.4891338348	0.4857361317	0.003397703171
12	0.09591698647	0.09096002579	0.004956960678	0.08040595055	0.07580208778	0.004603862762	0.239287138	0.2354791164	0.003808021545	0.5445141792	0.5411372185	0.003376960754
13	0.04590010643	0.04089093208	0.005009174347	0.3248591423	0.3207709789	0.004088163376	0.2391660213	0.2353129387	0.003853082657	0.2323930264	0.2289361954	0.003456830978
14	0.1156449318	0.1110038757	0.004641056061	0.05376386642	0.04913187027	0.004631996155	0.3104760647	0.3067338467	0.003742218018	0.5707700253	0.5673668385	0.003403186798
15	0.05009102821	0.04510688782	0.004984140396	0.1646389961	0.1600060463	0.004632949829	0.3213989735	0.317699194	0.00369977951	0.2921590805	0.2745471001	0.01761198044
16	0.03526902199	0.03060007095	0.004668951035	0.06458282471	0.06043696404	0.004145860672	0.2696819305	0.2658557892	0.003826141357	0.2652790546	0.261661768	0.003617286682
17	0.04555988312	0.04096508026	0.004594802856	0.06347608566	0.05882120132	0.004654884338	0.3209969997	0.3173058033	0.003691196442	0.2703211308	0.2669100761	0.003411054611
18	0.1913621426	0.1865980625	0.004764080048	0.1556949615	0.1513819695	0.004312992096	0.3697030544	0.3547532558	0.01494979858	0.4086670876	0.3914349079	0.01723217964
19	0.04314398766	0.03861379623	0.004530191422	0.09589195251	0.09150290489	0.004389047623	0.2747619152	0.271048069	0.003713846207	0.5454671383	0.5420908928	0.003376245499
20	0.04755806923	0.04266905785	0.004889011383	0.06661391258	0.04902100563	0.01759290695	0.3035228252	0.2890472412	0.01447558403	0.4147801399	0.4113249779	0.003455162048
21	0.05605888367	0.05124926567	0.004809617996	0.05449509621	0.05004310608	0.00445199128	0.3825461864	0.3788638115	0.003682374954	0.4574379921	0.4540278912	0.003410100937
22	0.03416991234	0.02944779396	0.004722118378	0.06143689156	0.05707287788	0.004364013672	0.3142619133	0.3105349541	0.003726959229	0.5615239143	0.5581538677	0.003370046616
23	0.05132508278	0.04521584511	0.006109237671	0.06463098526	0.06016039848	0.004470586777	0.3454620838	0.3307909966	0.01467108727	0.3910498619	0.3739349842	0.0171148777
Min	0.03416991234	0.02944779396	0.004525899887	0.04830598831	0.04370498657	0.004088163376	0.07885503769	0.07544493675	0.003332853317	0.2323930264	0.2289361954	0.003347873688
Avg	0.3359630108	0.3309881687	0.006109237671	0.3248591423	0.3207709789	0.01759290695	0.3825461864	0.3788638115	0.01494979858	0.5707700253	0.5673668385	0.01761198044
Max	0.1030129972	0.09818283371	0.004830163458	0.09557648327	0.09009098593	0.005477397338	0.2837696386	0.2772354147	0.006534223971	0.4242557028	0.4185761161	0.005679586659