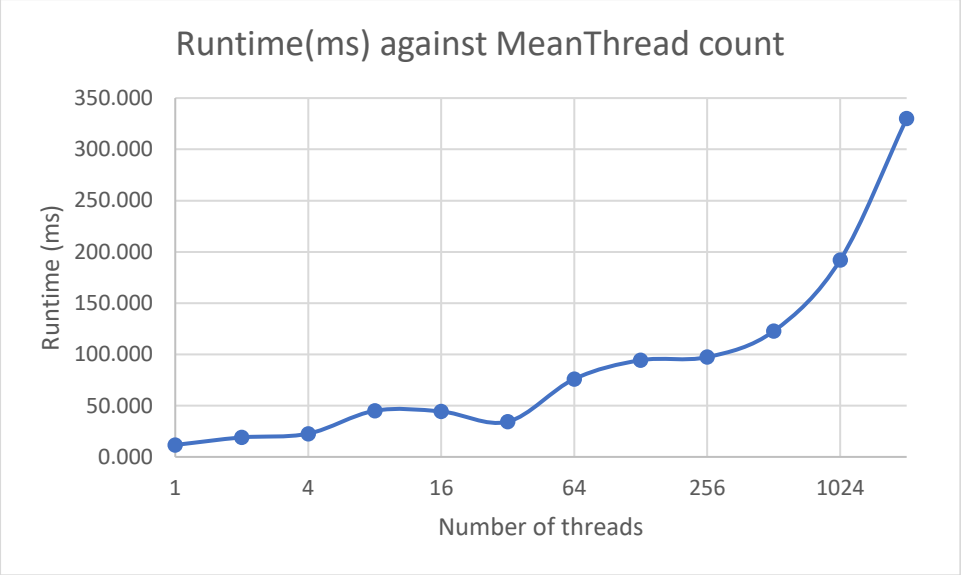
Mean Thread

thread	timing (ms)					20% trimmed mean
1	11	11	12	12	13	11.667
2	18	19	19	19	20	19.000
4	21	22	22	24	28	22.667
8	29	44	44	47	48	45.000
16	39	43	44	46	75	44.333
32	31	32	33	38	81	34.333
64	73	73	75	80	112	76.000
128	80	94	94	95	95	94.333
256	86	91	99	102	107	97.333
512	115	119	121	128	129	122.667
1024	179	189	192	195	199	192.000
2048	314	327	330	333	334	330.000



Screenshots of the output of MeanThread programs are included in the annex respectively.

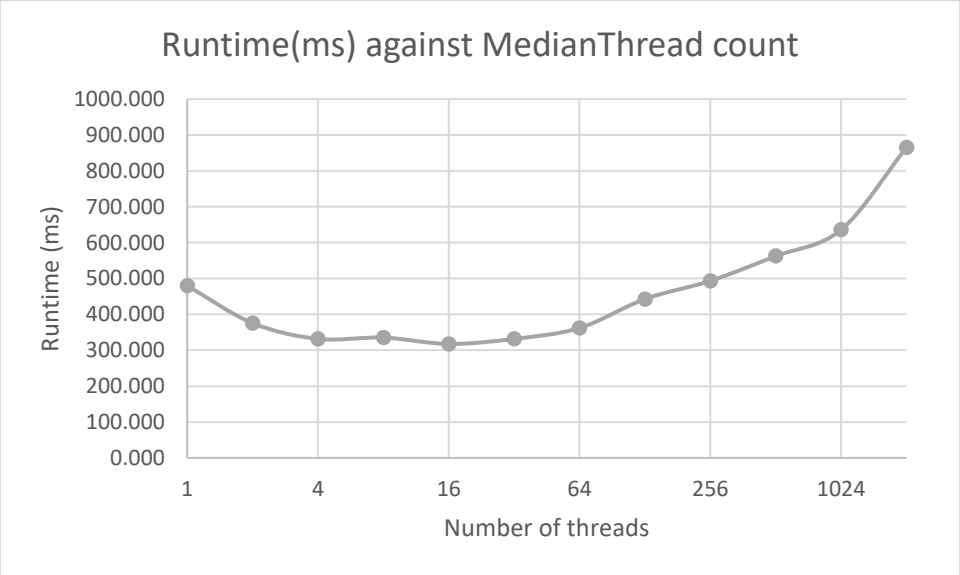
Runtime of the mean threads was measured without printing the temporal means of the individual threads. The program was ran at the specified thread count 5 times and the 20% trimmed mean was used to plot the graphs.

Runtime increases exponentially with the number of threads used. This could be due to the overhead from starting multiple threads. The runtime of the threads can also be affected by CPU resources or RAM of the computer).

The variance amongst runtimes of the same threads can be attributed to the fact that the programs were ran for the first time, so more time is needed to load the data into the cache.

Median Thread

thread	timing (ms)					20% trimmed mean
1	472	472	479	488	494	479.667
2	364	367	377	383	399	375.667
4	283	329	330	336	339	331.667
8	272	331	332	343	344	335.333
16	307	313	319	321	328	317.667
32	326	328	330	337	382	331.667
64	352	356	365	365	518	362.000
128	413	436	443	449	502	442.667
256	462	477	482	521	521	493.333
512	511	551	561	575	607	562.333
1024	612	631	636	640	648	635.667
2048	847	848	870	877	897	865.000



Screenshots of the output of MedianThread program is included in the annex. Runtime of the median thread was measured without printing out the entire sorted arrays. As with the mean thread the runtime of each thread count was measured 5 times and the 20% trimmed mean used to plot the graph above.

Runtime initially decreased before increasing exponentially after beyond 16 thread counts. This could be because multi thread programming for calculating the median is initially effective however beyond 16 threads, there began to be significant overhead from running and starting the threads, resulting in the exponential increase.

Runtime could also be affected by CPU resources and Ram available.

Annex

Output from MeanThrea.java

Command Prompt

```
C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 1
Temporal mean value of thread 0 is 5002.019383430481
Total execution time: 14
The global mean value is 5002.019383430481

C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>javac MeanThread.java

C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 1
Temporal mean value of thread 0 is 5002.019383430481
Total execution time: 13 milliseconds.
The global mean value is 5002.019383430481

C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 2
Temporal mean value of thread 0 is 5000.948331832886
Temporal mean value of thread 1 is 5003.090435028076
Total execution time: 19 milliseconds.
The global mean value is 5002.019383430481

C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 4
Temporal mean value of thread 0 is 4996.885913848877
Temporal mean value of thread 1 is 5005.0107498168945
Temporal mean value of thread 2 is 5000.335964202881
Temporal mean value of thread 3 is 5005.844905853271 5
Total execution time: 24 milliseconds.
The global mean value is 5002.019383430481

C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 8
Temporal mean value of thread 0 is 4995.028823852539
Temporal mean value of thread 1 is 4998.743003845215
Temporal mean value of thread 2 is 5015.597785949707
Temporal mean value of thread 3 is 4994.423713684082
Temporal mean value of thread 4 is 5003.888244628906
Temporal mean value of thread 5 is 4996.7836837768555
Temporal mean value of thread 6 is 5003.217643737793
Temporal mean value of thread 7 is 5008.47216796875
Total execution time: 45 milliseconds.
The global mean value is 5002.019383430481


C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 16
Temporal mean value of thread 0 is 4984.044342041016
Temporal mean value of thread 1 is 5006.0133056640625
Temporal mean value of thread 2 is 4996.07345703125
Temporal mean value of thread 3 is 5001.406661987305
Temporal mean value of thread 4 is 5003.930252075195
Temporal mean value of thread 5 is 5027.265319824219
Temporal mean value of thread 6 is 4986.04638671875
Temporal mean value of thread 7 is 5002.801040649414
Temporal mean value of thread 8 is 5020.112518310547
Temporal mean value of thread 9 is 4987.663970947266
Temporal mean value of thread 10 is 5000.725036621094
Temporal mean value of thread 11 is 4992.842230932617
Temporal mean value of thread 12 is 5003.167785644531
Temporal mean value of thread 13 is 5003.267501831055
Temporal mean value of thread 14 is 5010.052230834961
Temporal mean value of thread 15 is 5006.892105102539
Total execution time: 29 milliseconds.
The global mean value is 5002.019383430481

C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 32
Temporal mean value of thread 0 is 5003.316009521484
Temporal mean value of thread 1 is 4964.772674560547
Temporal mean value of thread 2 is 4988.205688476562 5
Temporal mean value of thread 3 is 5023.820922851562 5
Temporal mean value of thread 4 is 4988.783782958984
Temporal mean value of thread 5 is 5003.374908447266
Temporal mean value of thread 6 is 4991.097190486328
Temporal mean value of thread 7 is 5011.716125488281
Temporal mean value of thread 8 is 5004.753814697266
Temporal mean value of thread 9 is 5003.106689453125
Temporal mean value of thread 10 is 5037.984466552734
Temporal mean value of thread 11 is 5016.546173095703
Temporal mean value of thread 12 is 4983.513488769531
Temporal mean value of thread 13 is 4988.57928466796 9
Temporal mean value of thread 14 is 4994.291198730469
Temporal mean value of thread 15 is 5011.310882568359
Temporal mean value of thread 16 is 5028.301230013672
Temporal mean value of thread 17 is 5011.923797607422
Temporal mean value of thread 18 is 4989.389678955078
Temporal mean value of thread 19 is 4985.938262939453
Temporal mean value of thread 20 is 5007.778228759766
Temporal mean value of thread 21 is 4993.671844482422
Temporal mean value of thread 22 is 4988.2335205078125
Temporal mean value of thread 23 is 4997.451141357422
Temporal mean value of thread 24 is 5001.253417968 75
Temporal mean value of thread 25 is 5005.082153320312 5
Temporal mean value of thread 26 is 5004.036285400391
Temporal mean value of thread 27 is 5002.498718261719
Temporal mean value of thread 28 is 5006.61083984375
Temporal mean value of thread 29 is 5013.493621826172
Temporal mean value of thread 30 is 5007.197021484375
Temporal mean value of thread 31 is 5006.587188720703
Total execution time: 76 milliseconds.
The global mean value is 5002.019383430481


C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 64
Temporal mean value of thread 0 is 4959.4010009765625
Temporal mean value of thread 1 is 5047.2310180664 06
Temporal mean value of thread 2 is 4975.6983642578125
Temporal mean value of thread 3 is 4953.846984863281
Temporal mean value of thread 4 is 4961.565002441406
Temporal mean value of thread 5 is 5014.846374511719
Temporal mean value of thread 6 is 5025.976684570312 5
Temporal mean value of thread 7 is 5021.665161132812 5
Temporal mean value of thread 8 is 4981.955200195312 5
Temporal mean value of thread 9 is 4995.612365722656
Temporal mean value of thread 10 is 5000.365905761719
Temporal mean value of thread 11 is 5006.3839111328125
Temporal mean value of thread 12 is 4985.759277343 75
Temporal mean value of thread 13 is 4996.435119628906
Temporal mean value of thread 14 is 5008.165222167969
Temporal mean value of thread 15 is 5015.267028808594
Temporal mean value of thread 16 is 4997.009521 57812 5
Temporal mean value of thread 17 is 5011.602111816406
Temporal mean value of thread 18 is 4995.365051269531
Temporal mean value of thread 19 is 5010.848327636719
Temporal mean value of thread 20 is 5007.327453613281
Temporal mean value of thread 21 is 5008.641479492187 5
Temporal mean value of thread 22 is 5019.316284179687 5
Temporal mean value of thread 23 is 5013.776062011719
Temporal mean value of thread 24 is 5018.1295166015625
Temporal mean value of thread 25 is 4988.897460937 5
Temporal mean value of thread 26 is 4988.279968261719
Temporal mean value of thread 27 is 4988.878601074219
Temporal mean value of thread 28 is 5030.320068359375
Temporal mean value of thread 29 is 4958.262329101562 5
Temporal mean value of thread 30 is 5015.200317382812 5
Temporal mean value of thread 31 is 5007.421447753906
Temporal mean value of thread 32 is 5031.574523925781
Temporal mean value of thread 33 is 5025.027954101562 5
Temporal mean value of thread 34 is 4982.946960449219
Temporal mean value of thread 35 is 5040.900634765625
Temporal mean value of thread 36 is 5031.22119140625
Temporal mean value of thread 37 is 4947.558166503906
Temporal mean value of thread 38 is 4983.076477050781
Temporal mean value of thread 39 is 4988.800048828125
Temporal mean value of thread 40 is 5023.962158203125
Temporal mean value of thread 41 is 4991.594299316406
Temporal mean value of thread 42 is 4993.517272949219
Temporal mean value of thread 43 is 4993.826416015625
Temporal mean value of thread 44 is 4989.813598632812 5
Temporal mean value of thread 45 is 4986.653442382812 5
Temporal mean value of thread 46 is 4974.767211914062 5
Temporal mean value of thread 47 is 5020.135078800781
Temporal mean value of thread 48 is 5021.341674804687 5
Temporal mean value of thread 49 is 4981.165161132812 5
Temporal mean value of thread 50 is 5009.670227050781
Temporal mean value of thread 51 is 5000.404079589844
Temporal mean value of thread 52 is 4998.092161035937 5
Temporal mean value of thread 53 is 5009.980407714844
Temporal mean value of thread 54 is 4982.298400878906
Temporal mean value of thread 55 is 5022.699035644531
Temporal mean value of thread 56 is 5002.091674804687 5
Temporal mean value of thread 57 is 5011.130004882812 5
Temporal mean value of thread 58 is 4988.261657714844
Temporal mean value of thread 59 is 5018.725585937 5
Temporal mean value of thread 60 is 5018.990295410156
Temporal mean value of thread 61 is 4995.403747558594
Temporal mean value of thread 62 is 4990.137817382812 5
Temporal mean value of thread 63 is 5023.036560058594
Total execution time: 85 milliseconds.
The global mean value is 5002.019383430481

C:\Users\Jing Yun\Desktop\50.005 Computer Systems Engineering\50.005-CSE-Labs\Lab2>java MeanThread input.txt 128
Temporal mean value of thread 0 is 4895.120971679687 5
Temporal mean value of thread 1 is 5023.681030273437 5
Temporal mean value of thread 2 is 5045.700927734375
Temporal mean value of thread 3 is 5048.761108398437 5
Temporal mean value of thread 4 is 4963.34765625
Temporal mean value of thread 5 is 4988.849072265625
Temporal mean value of thread 6 is 4941.980834960937 5
Temporal mean value of thread 7 is 4965.713134765625
Temporal mean value of thread 8 is 4970.09716796875
Temporal mean value of thread 9 is 4953.032836914062 5
Temporal mean value of thread 10 is 5018.502685546875
Temporal mean value of thread 11 is 5011.190063476562 5
Temporal mean value of thread 12 is 5028.744628906 25
Temporal mean value of thread 13 is 5023.208740234375
Temporal mean value of thread 14 is 5047.96875
Temporal mean value of thread 15 is 4995.361572265625
Temporal mean value of thread 16 is 4982.859741210937 5
Temporal mean value of thread 17 is 4981.050659179687 5
Temporal mean value of thread 18 is 4994.591430664062 5
```

Output from Median Thread program