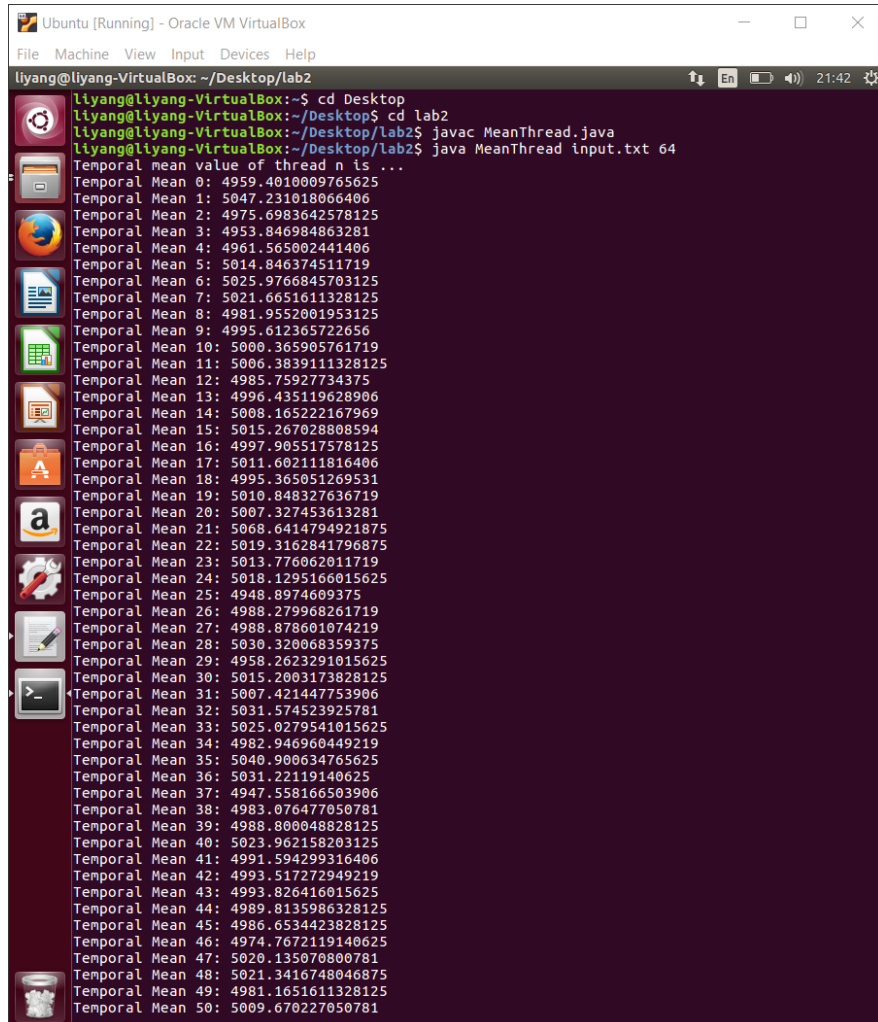


Lab 2

1.1 Find Mean of an Array Using Multi-thread in Java

Intermediate and Global Mean Values

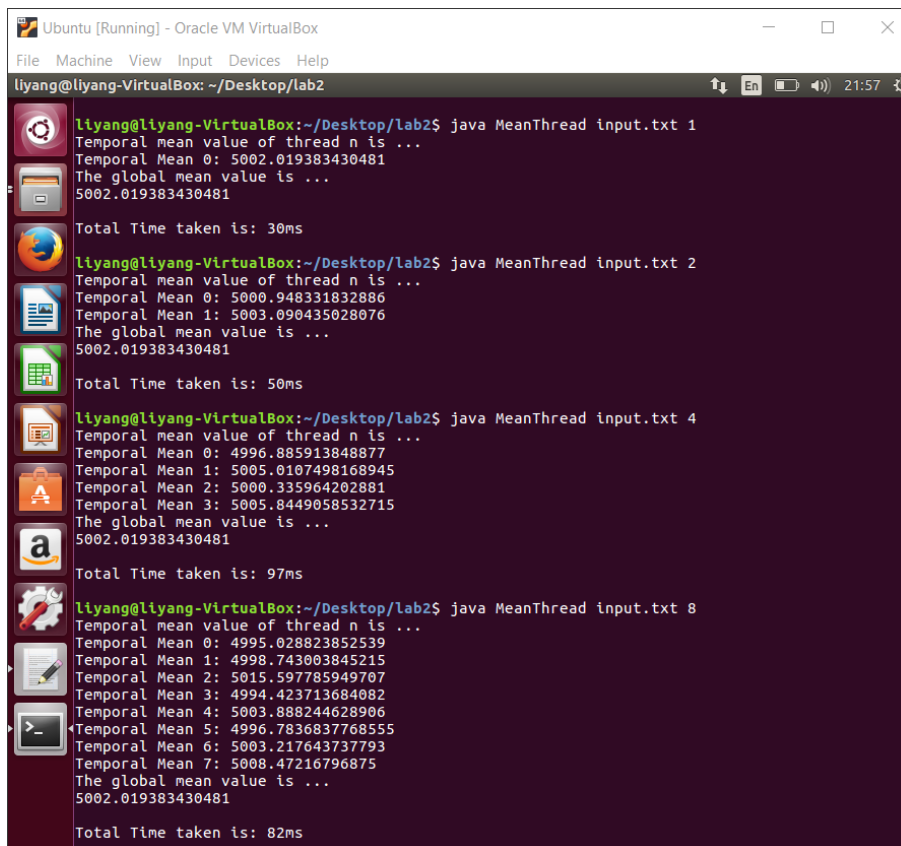


```
liyang@liyang-VirtualBox: ~/Desktop/lab2
liyang@liyang-VirtualBox:~$ cd Desktop
liyang@liyang-VirtualBox:~/Desktop$ cd lab2
liyang@liyang-VirtualBox:~/Desktop/lab2$ javac MeanThread.java
liyang@liyang-VirtualBox:~/Desktop/lab2$ java MeanThread input.txt 64
Temporal mean value of thread n is ...
Temporal Mean 0: 4959.401009765625
Temporal Mean 1: 5047.231018066406
Temporal Mean 2: 4975.6983642578125
Temporal Mean 3: 4953.846984863281
Temporal Mean 4: 4961.565002441406
Temporal Mean 5: 5014.846374511719
Temporal Mean 6: 5025.9766845703125
Temporal Mean 7: 5021.6651611328125
Temporal Mean 8: 4981.9552001953125
Temporal Mean 9: 4995.612365722656
Temporal Mean 10: 5000.365905761719
Temporal Mean 11: 5006.3839111328125
Temporal Mean 12: 4985.75927734375
Temporal Mean 13: 4996.435119628906
Temporal Mean 14: 5008.165222167969
Temporal Mean 15: 5015.267028808594
Temporal Mean 16: 4997.905517578125
Temporal Mean 17: 5011.602111816406
Temporal Mean 18: 4995.365051269531
Temporal Mean 19: 5010.848327636719
Temporal Mean 20: 5007.327453613281
Temporal Mean 21: 5068.6414794921875
Temporal Mean 22: 5019.3162841796875
Temporal Mean 23: 5013.776062011719
Temporal Mean 24: 5018.1295166015625
Temporal Mean 25: 4948.8974609375
Temporal Mean 26: 4988.279968261719
Temporal Mean 27: 4988.878601074219
Temporal Mean 28: 5030.320068359375
Temporal Mean 29: 4958.2623291015625
Temporal Mean 30: 5015.2003173828125
Temporal Mean 31: 5007.421447753906
Temporal Mean 32: 5031.574523925781
Temporal Mean 33: 5025.0279541015625
Temporal Mean 34: 4982.946960449219
Temporal Mean 35: 5040.900634765625
Temporal Mean 36: 5031.22119140625
Temporal Mean 37: 4947.558166503906
Temporal Mean 38: 4983.076477050781
Temporal Mean 39: 4988.800048828125
Temporal Mean 40: 5023.962158203125
Temporal Mean 41: 4991.594299316406
Temporal Mean 42: 4993.517272949219
Temporal Mean 43: 4993.826416015625
Temporal Mean 44: 4989.8135986328125
Temporal Mean 45: 4986.6534423828125
Temporal Mean 46: 4974.7672119140625
Temporal Mean 47: 5020.135070800781
Temporal Mean 48: 5021.3416748046875
Temporal Mean 49: 4981.1651611328125
Temporal Mean 50: 5009.670227050781
```

```
Ubuntu [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
liyang@liyang-VirtualBox: ~/Desktop/lab2
Temporal Mean 14: 5008.165222167969
Temporal Mean 15: 5015.267028808594
Temporal Mean 16: 4997.905517578125
Temporal Mean 17: 5011.602111816406
Temporal Mean 18: 4995.365051269531
Temporal Mean 19: 5010.848327636719
Temporal Mean 20: 5007.327453613281
Temporal Mean 21: 5068.6414794921875
Temporal Mean 22: 5019.3162841796875
Temporal Mean 23: 5013.776062011719
Temporal Mean 24: 5018.1295166015625
Temporal Mean 25: 4948.8974609375
Temporal Mean 26: 4988.279968261719
Temporal Mean 27: 4988.878601074219
Temporal Mean 28: 5030.320068359375
Temporal Mean 29: 4958.2623291015625
Temporal Mean 30: 5015.2003173828125
Temporal Mean 31: 5007.421447753906
Temporal Mean 32: 5031.574523925781
Temporal Mean 33: 5025.0279541015625
Temporal Mean 34: 4982.946960449219
Temporal Mean 35: 5040.900634765625
Temporal Mean 36: 5031.22119140625
Temporal Mean 37: 4947.558166503906
Temporal Mean 38: 4983.076477050781
Temporal Mean 39: 4988.800048828125
Temporal Mean 40: 5023.962158203125
Temporal Mean 41: 4991.594299316406
Temporal Mean 42: 4993.517272949219
Temporal Mean 43: 4993.826416015625
Temporal Mean 44: 4989.8135986328125
Temporal Mean 45: 4986.6534423828125
Temporal Mean 46: 4974.7672119140625
Temporal Mean 47: 5020.135070800781
Temporal Mean 48: 5021.3416748046875
Temporal Mean 49: 4981.1651611328125
Temporal Mean 50: 5009.670227050781
Temporal Mean 51: 5000.494079589844
Temporal Mean 52: 4998.0921630859375
Temporal Mean 53: 5009.980407714844
Temporal Mean 54: 4982.298400879906
Temporal Mean 55: 5022.699035644531
Temporal Mean 56: 5002.0916748046875
Temporal Mean 57: 5011.1300048828125
Temporal Mean 58: 4988.261657714844
Temporal Mean 59: 5038.7255859375
Temporal Mean 60: 5018.990295410156
Temporal Mean 61: 4995.403747558594
Temporal Mean 62: 4990.1378173828125
Temporal Mean 63: 5023.036560058594
The global mean value is ...
5002.019383430481
Total Time taken is: 189ms
liyang@liyang-VirtualBox:~/Desktop/lab2$
```

Record Execution Time

At thread = 1 to thread = 8,



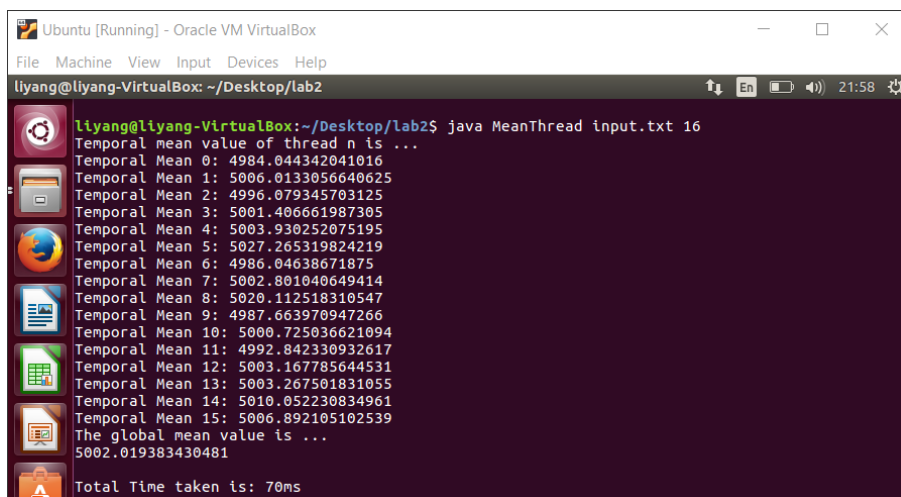
```
liyang@liyang-VirtualBox: ~/Desktop/lab2
liyang@liyang-VirtualBox:~/Desktop/lab2$ java MeanThread input.txt 1
Temporal mean value of thread n is ...
Temporal Mean 0: 5002.019383430481
The global mean value is ...
5002.019383430481
Total Time taken is: 30ms

liyang@liyang-VirtualBox:~/Desktop/lab2$ java MeanThread input.txt 2
Temporal mean value of thread n is ...
Temporal Mean 0: 5000.948331832886
Temporal Mean 1: 5003.090435028076
The global mean value is ...
5002.019383430481
Total Time taken is: 50ms

liyang@liyang-VirtualBox:~/Desktop/lab2$ java MeanThread input.txt 4
Temporal mean value of thread n is ...
Temporal Mean 0: 4996.885913848877
Temporal Mean 1: 5005.0107498168945
Temporal Mean 2: 5000.335964202881
Temporal Mean 3: 5005.8449058532715
The global mean value is ...
5002.019383430481
Total Time taken is: 97ms

liyang@liyang-VirtualBox:~/Desktop/lab2$ java MeanThread input.txt 8
Temporal mean value of thread n is ...
Temporal Mean 0: 4995.028823852539
Temporal Mean 1: 4998.743003845215
Temporal Mean 2: 5015.597785949707
Temporal Mean 3: 4994.423713684082
Temporal Mean 4: 5003.888244628906
Temporal Mean 5: 4996.7836837768555
Temporal Mean 6: 5003.217643737793
Temporal Mean 7: 5008.47216796875
The global mean value is ...
5002.019383430481
Total Time taken is: 82ms
```

At thread = 16,



```
liyang@liyang-VirtualBox: ~/Desktop/lab2
liyang@liyang-VirtualBox:~/Desktop/lab2$ java MeanThread input.txt 16
Temporal mean value of thread n is ...
Temporal Mean 0: 4984.044342041016
Temporal Mean 1: 5006.0133056640625
Temporal Mean 2: 4996.079345703125
Temporal Mean 3: 5001.406661987305
Temporal Mean 4: 5003.930252075195
Temporal Mean 5: 5027.265319824219
Temporal Mean 6: 4986.04638671875
Temporal Mean 7: 5002.801040649414
Temporal Mean 8: 5020.112518310547
Temporal Mean 9: 4987.663970947266
Temporal Mean 10: 5000.725036621094
Temporal Mean 11: 4992.842330932617
Temporal Mean 12: 5003.167785644531
Temporal Mean 13: 5003.267501831055
Temporal Mean 14: 5010.052230834961
Temporal Mean 15: 5006.892105102539
The global mean value is ...
5002.019383430481
Total Time taken is: 70ms
```

At thread = 32,

```
Temporal Mean 21: 4993.671844482422
Temporal Mean 22: 4988.2335205078125
Temporal Mean 23: 4997.451141357422
Temporal Mean 24: 5001.25341796875
Temporal Mean 25: 5005.0821533203125
Temporal Mean 26: 5004.036285400391
Temporal Mean 27: 5002.498718261719
Temporal Mean 28: 5006.61083984375
Temporal Mean 29: 5013.493621826172
Temporal Mean 30: 5007.197021484375
Temporal Mean 31: 5006.587188720703
The global mean value is ...
5002.019383430481

Total Time taken is: 67ms
liyang@liyang-VirtualBox:~/Desktop/lab2$
```

At thread = 128,

```
Temporal Mean 105: 5005.1988525390625
Temporal Mean 106: 5057.28662109375
Temporal Mean 107: 4962.6741943359375
Temporal Mean 108: 4996.667724609375
Temporal Mean 109: 4967.9290771484375
Temporal Mean 110: 5044.137451171875
Temporal Mean 111: 5001.2606201171875
Temporal Mean 112: 4974.8291015625
Temporal Mean 113: 5029.354248046875
Temporal Mean 114: 4993.34619140625
Temporal Mean 115: 5028.913818359375
Temporal Mean 116: 4997.9398193359375
Temporal Mean 117: 4978.58349609375
Temporal Mean 118: 5050.99072265625
Temporal Mean 119: 5026.46044921875
Temporal Mean 120: 5034.2283935546875
Temporal Mean 121: 5003.752197265625
Temporal Mean 122: 4997.7333984375
Temporal Mean 123: 4993.0740966796875
Temporal Mean 124: 4930.431640625
Temporal Mean 125: 5049.843994140625
Temporal Mean 126: 5057.072509765625
Temporal Mean 127: 4989.0006103515625
The global mean value is ...
5002.019383430481

Total Time taken is: 106ms
liyang@liyang-VirtualBox:~/Desktop/lab2$
```

At thread = 512,

```
Temporal Mean 491: 5031.69873046875
Temporal Mean 492: 4964.3134765625
Temporal Mean 493: 4905.4423828125
Temporal Mean 494: 5093.73828125
Temporal Mean 495: 5008.80224609375
Temporal Mean 496: 4914.95703125
Temporal Mean 497: 4981.02197265625
Temporal Mean 498: 4925.23779296875
Temporal Mean 499: 4900.509765625
Temporal Mean 500: 5197.06591796875
Temporal Mean 501: 4977.56689453125
Temporal Mean 502: 5047.86474609375
Temporal Mean 503: 4976.87841796875
Temporal Mean 504: 5126.4912109375
Temporal Mean 505: 5033.76171875
Temporal Mean 506: 5124.1435546875
Temporal Mean 507: 4943.8935546875
Temporal Mean 508: 4909.6396484375
Temporal Mean 509: 5021.60498046875
Temporal Mean 510: 4985.2744140625
Temporal Mean 511: 5039.4833984375
The global mean value is ...
5002.019383430481

Total Time taken is: 332ms
liyang@liyang-VirtualBox:~/Desktop/lab2$
```

At thread = 1024,

```
Temporal Mean 1004: 5093.66015625
Temporal Mean 1005: 5002.0693359375
Temporal Mean 1006: 4947.970703125
Temporal Mean 1007: 5005.7861328125
Temporal Mean 1008: 4999.826171875
Temporal Mean 1009: 5253.15625
Temporal Mean 1010: 5100.234375
Temporal Mean 1011: 4967.2890625
Temporal Mean 1012: 5166.05078125
Temporal Mean 1013: 5082.236328125
Temporal Mean 1014: 4840.3525390625
Temporal Mean 1015: 5047.4345703125
Temporal Mean 1016: 4882.861328125
Temporal Mean 1017: 4936.41796875
Temporal Mean 1018: 5036.2158203125
Temporal Mean 1019: 5006.994140625
Temporal Mean 1020: 5088.595703125
Temporal Mean 1021: 4881.953125
Temporal Mean 1022: 5058.80859375
Temporal Mean 1023: 5020.158203125
The global mean value is ...
5002.019383430481

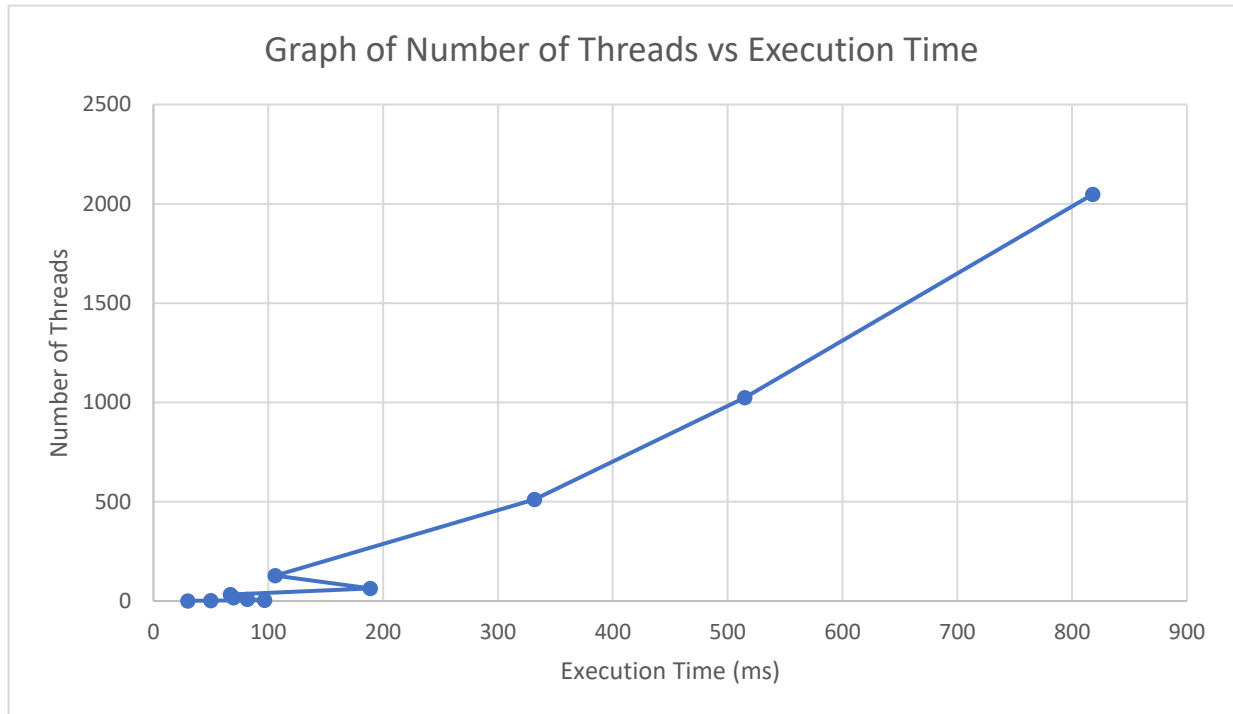
Total Time taken is: 515ms
liyang@liyang-VirtualBox:~/Desktop/lab2$
```

At thread = 2048,

```
Temporal Mean 2029: 4809.421875
Temporal Mean 2030: 4970.09765625
Temporal Mean 2031: 5124.771484375
Temporal Mean 2032: 4895.787109375
Temporal Mean 2033: 4869.935546875
Temporal Mean 2034: 5106.75390625
Temporal Mean 2035: 4766.08203125
Temporal Mean 2036: 5080.201171875
Temporal Mean 2037: 4992.23046875
Temporal Mean 2038: 5082.376953125
Temporal Mean 2039: 4931.611328125
Temporal Mean 2040: 5019.861328125
Temporal Mean 2041: 5157.330078125
Temporal Mean 2042: 4960.587890625
Temporal Mean 2043: 4803.318359375
Temporal Mean 2044: 5031.87890625
Temporal Mean 2045: 5085.73828125
Temporal Mean 2046: 4806.095703125
Temporal Mean 2047: 5234.220703125
The global mean value is ...
5002.019383430481

Total Time taken is: 818ms
liyang@liyang-VirtualBox:~/Desktop/lab2$
```

Number of Threads	1	2	4	8	16	32	64	128	512	1024	2048
Execution Time(ms)	30	50	97	82	70	67	189	106	332	515	818



1.2 Find Median of an Array Using Multi-thread in Java

Median of Array

[illegible]

Record Execution Time

At thread = 1,

[illegible]

At thread = 2,

[illegible]

At thread = 4,

[illegible]

At thread = 8,

[illegible]

At thread = 16.

[illegible]

At thread = 32,

[illegible]

At thread = 128,

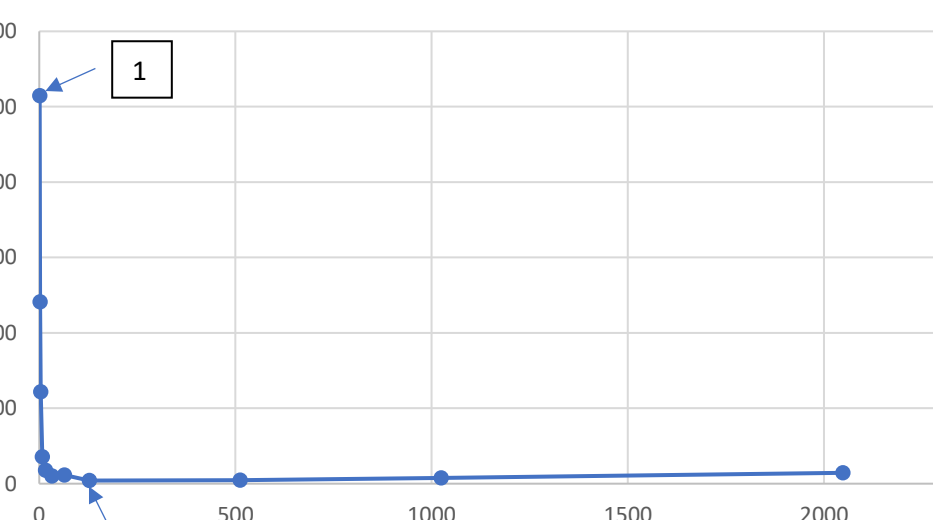
[illegible]

At thread =512,

[illegible]

At thread = 1024,

[illegible]

[illegible]

The graph, titled "Graph of Execution Time vs Number of Threads", plots Execution Time (ms) on the y-axis (0 to 300,000) against the Number of Threads on the x-axis (0 to 2,500). The data points show a sharp decrease in execution time as the number of threads increases from 1 to 128, after which the time remains relatively constant and low. A blue arrow points to the data point at 1 thread, and another blue arrow points to the data point at 128 threads. Both points are highlighted with black boxes containing their respective thread counts.

Number of Threads	Execution Time (ms)
1	258,000
2	120,000
4	60,000
8	18,000
16	5,000
32	5,000
64	2,000
128	1,000
256	1,000
512	1,000
1024	1,000
2048	1,000

For Mean, as the number of threads increases, the execution time also increases.