## Program Structures and Algorithms Spring 2023(SEC –03)

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**Task:** Compare parallel sort results with default sort provided by Java. Set multiple cut-off values to check which after which value parallel sort with multi-threading should be applied. Here, I have taken three different array size, which are 50000, 100000 and 1000000. For each example, cut-off values are divided in 5% of the array size.

**Relationship Conclusion:** As the array size increases, the more threads help sort the data faster than less threads. Also, the cut-off value between 10% to 20% gives fastest time with 8 to 16 threads.

## Evidence to support that conclusion and graphical representation:

The cut-off values are in gap of 5% of the array size.

For array size 50000: Best results were found with cut-off 20000 (40%) and 4,8 and 16 threads.

Fir array size 100000: Best results were found with cut-off 25000 (25%) and 8 threads. For array size 1000000: Best results were found with cut-off 50000 (5%) and 32 threads.

Thus, from these values, we can say that as the size of data increases, low cut-off value with more threads will give the best results.

Here, horizontal headings represents threads and Vertical titles represents the cut-off value.

Array Size: 50000					
	2	4	8	16	32
2500	73ms	20ms	19ms	17ms	16ms
5000	48ms	15ms	14ms	12ms	14ms
7500	41ms	14ms	14ms	13ms	13ms
10000	20ms	16ms	13ms	12ms	14ms
12500	18ms	15ms	14ms	14ms	13ms
15000	18ms	13ms	13ms	12ms	13ms
17500	25ms	13ms	13ms	12ms	13ms
20000	26ms	12ms	12ms	12ms	13ms
22500	19ms	13ms	13ms	13ms	13ms
25000	18ms	13ms	12ms	13ms	12ms
27500	18ms	17ms	17ms	16ms	17ms
30000	17ms	17ms	16ms	17ms	16ms
32500	18ms	16ms	16ms	16ms	16ms
35000	17ms	17ms	16ms	17ms	16ms

37500   23ms   16ms   16ms   16ms   16ms     40000   17ms   16ms   17ms   17ms   16ms     42500   16ms   17ms   16ms   17ms   16ms   17ms   16ms     45000   17ms   16ms   16ms   17ms   16ms   16ms   16ms     47500   16ms   17ms   16ms   16ms   16ms   16ms     50000   17ms   16ms   16ms   16ms   16ms     47500   16ms   16ms   16ms   16ms     47ms   16ms   16ms   16ms   16ms     4000   109ms   39ms   33ms   31ms   26ms     25m0   109ms   39ms   33ms   31ms   26ms     25ms   25ms   25ms   25ms   24ms   26ms     25000   35ms   25ms   25ms   25ms   25ms     35000   43ms   26ms   25ms   25ms   25ms						
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45000   17ms   16ms   17ms   16ms   26ms   25ms   24ms   25ms   25ms   25ms   25ms   25ms   25ms   25ms   25ms <t< th=""><th>40000</th><th>17ms</th><th>16ms</th><th>17ms</th><th>17ms</th><th>16ms</th></t<>	40000	17ms	16ms	17ms	17ms	16ms
47500   16ms   17ms   16ms   26ms   25ms   26ms   25ms   25ms   27ms   26ms   24ms   24ms   24ms   24ms   24ms   25ms   25ms <t< th=""><th>42500</th><th>16ms</th><th>17ms</th><th>17ms</th><th>16ms</th><th>17ms</th></t<>	42500	16ms	17ms	17ms	16ms	17ms
50000   17ms   16ms   16ms   16ms   16ms     Array Size: 100000	45000	17ms	16ms	16ms	17ms	16ms
Array Size: 100000	47500	16ms	17ms	17ms	16ms	16ms
2   4   8   16   32     5000   109ms   39ms   33ms   31ms   26ms     10000   70ms   28ms   26ms   25ms   27ms     15000   36ms   27ms   26ms   24ms   26ms     20000   35ms   26ms   23ms   24ms   24ms     25000   35ms   25ms   25ms   25ms   25ms     30000   50ms   25ms   25ms   25ms   25ms     35000   43ms   25ms   25ms   25ms   25ms     40000   38ms   26ms   25ms   25ms   25ms     45000   37ms   26ms   26ms   26ms   25ms     55000   35ms   33ms   33ms   33ms   33ms   34ms     55000   34ms   34ms   34ms   33ms   33ms   33ms   33ms     75000   34ms   34ms   33ms   33ms   33ms   33ms   33ms	50000	17ms	16ms	16ms	16ms	16ms
2   4   8   16   32     5000   109ms   39ms   33ms   31ms   26ms     10000   70ms   28ms   26ms   25ms   27ms     15000   36ms   27ms   26ms   24ms   26ms     20000   35ms   26ms   23ms   24ms   24ms     25000   35ms   25ms   25ms   25ms   25ms     30000   50ms   25ms   25ms   25ms   25ms     35000   43ms   25ms   25ms   25ms   25ms     40000   38ms   26ms   25ms   25ms   25ms     45000   37ms   26ms   26ms   26ms   25ms     55000   35ms   33ms   33ms   33ms   33ms   34ms     55000   34ms   34ms   34ms   33ms   33ms   33ms   33ms     75000   34ms   34ms   33ms   33ms   33ms   33ms   33ms						
5000   109ms   39ms   33ms   31ms   26ms     10000   70ms   28ms   26ms   25ms   27ms     15000   36ms   27ms   26ms   24ms   26ms     20000   35ms   27ms   25ms   24ms   24ms     25000   35ms   26ms   23ms   24ms   24ms     30000   50ms   25ms   25ms   25ms   25ms     35000   43ms   26ms   25ms   25ms   25ms   25ms     40000   38ms   26ms   26ms   26ms   26ms   26ms   26ms   25ms   33ms   33ms	Array Size	: 100000				
10000   70ms   28ms   26ms   25ms   27ms     15000   36ms   27ms   26ms   24ms   26ms     20000   35ms   27ms   25ms   24ms   24ms     25000   35ms   26ms   23ms   24ms   24ms     30000   50ms   25ms   25ms   25ms   25ms     35000   43ms   25ms   24ms   26ms   25ms     40000   38ms   26ms   25ms   25ms   25ms     45000   37ms   26ms   26ms   26ms   26ms     50000   38ms   25ms   25ms   25ms   25ms   25ms     55000   35ms   33ms   33ms   33ms   34ms   33ms		2	4	8	16	32
15000   36ms   27ms   26ms   24ms   26ms     20000   35ms   27ms   25ms   24ms   24ms     25000   35ms   26ms   23ms   24ms   24ms     30000   50ms   25ms   25ms   25ms   25ms     35000   43ms   25ms   24ms   26ms   25ms     40000   38ms   26ms   25ms   25ms   25ms     45000   37ms   26ms   26ms   26ms   26ms     50000   38ms   25ms   25ms   25ms   25ms     55000   35ms   33ms   33ms   33ms   34ms     65000   34ms   34ms   34ms   33ms   33ms   33ms     75000   34ms   34ms   33ms   33ms   33ms   33ms     85000   34ms   33ms   33ms   33ms   33ms   33ms     95000   34ms   33ms   34ms   33ms   33ms	5000	109ms	39ms	33ms	31ms	26ms
20000   35ms   27ms   25ms   24ms   24ms     25000   35ms   26ms   23ms   24ms   24ms     30000   50ms   25ms   25ms   25ms   25ms     35000   43ms   25ms   24ms   26ms   25ms     40000   38ms   26ms   25ms   25ms   25ms     45000   37ms   26ms   26ms   26ms   25ms   25ms     50000   38ms   25ms   25ms   25ms   25ms   25ms     50000   38ms   25ms   33ms   34ms   33ms	10000	70ms	28ms	26ms	25ms	27ms
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30000   50ms   25ms   25ms   25ms   25ms     35000   43ms   25ms   24ms   26ms   25ms     40000   38ms   26ms   25ms   25ms   25ms     45000   37ms   26ms   26ms   26ms   26ms     50000   38ms   25ms   25ms   25ms   25ms     55000   35ms   33ms   33ms   33ms   34ms     60000   34ms   34ms   34ms   33ms   33ms   33ms     70000   34ms   34ms   34ms   33ms   33ms   33ms     80000   34ms   34ms   33ms   33ms   33ms   33ms     85000   34ms   33ms   33ms   33ms   33ms   33ms     95000   34ms   33ms   34ms   32ms   34ms     100000   34ms   33ms   33ms   33ms   33ms     4   34ms   33ms   33ms   33ms   33m	20000	35ms	27ms	25ms	24ms	24ms
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40000   38ms   26ms   25ms   25ms   25ms     45000   37ms   26ms   26ms   26ms   26ms     50000   38ms   25ms   25ms   25ms   25ms     55000   35ms   33ms   33ms   34ms   34ms   33ms   33ms   33ms     60000   34ms   34ms   34ms   33ms   33ms   32ms     75000   34ms   34ms   33ms   34ms   33ms   33ms     80000   34ms   33ms   33ms   33ms   33ms     85000   34ms   33ms   33ms   33ms   33ms     95000   34ms   33ms   34ms   32ms   34ms     100000   34ms   33ms   33ms   33ms   33ms     4   33ms   33ms   33ms   33ms   33ms     33ms   33ms   33ms   33ms   33ms   33ms     35ms   33ms   33ms   33ms   33ms<	30000	50ms	25ms	25ms	25ms	25ms
45000   37ms   26ms   26ms   26ms   26ms     50000   38ms   25ms   25ms   25ms   25ms     55000   35ms   33ms   33ms   33ms   34ms     60000   34ms   34ms   34ms   33ms   33ms     65000   34ms   34ms   34ms   33ms   32ms     75000   34ms   34ms   33ms   33ms   33ms     85000   34ms   33ms   33ms   33ms   33ms     90000   34ms   33ms   33ms   33ms   33ms     95000   34ms   33ms   34ms   32ms   34ms     100000   34ms   33ms   34ms   33ms   33ms   33ms     4   34ms   33ms   34ms   33ms   33ms   33ms     30000   34ms   33ms   34ms   33ms   33ms   33ms     30000   34ms   33ms   33ms   33ms   33ms   33m	35000	43ms	25ms	24ms	26ms	25ms
50000   38ms   25ms   25ms   25ms   25ms     55000   35ms   33ms   33ms   34ms   34ms     60000   34ms   34ms   34ms   33ms   33ms   33ms     65000   34ms   34ms   34ms   33ms   32ms     75000   34ms   34ms   33ms   34ms   33ms     80000   34ms   33ms   33ms   33ms   33ms     85000   34ms   33ms   33ms   33ms   33ms     90000   33ms   33ms   33ms   33ms   33ms     95000   34ms   33ms   34ms   32ms   34ms     100000   34ms   33ms   33ms   33ms   33ms     4   34ms   33ms   33ms   33ms   33ms     33ms   34ms   33ms   33ms   33ms   33ms     33ms   33ms   33ms   33ms   33ms     33ms   33ms   33ms <th>40000</th> <th>38ms</th> <th>26ms</th> <th>25ms</th> <th>25ms</th> <th>25ms</th>	40000	38ms	26ms	25ms	25ms	25ms
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65000   34ms   33ms   33ms   33ms   33ms   33ms   33ms   33ms   32ms     75000   34ms   34ms   33ms   34ms   33ms   34ms	55000	35ms	33ms	33ms	33ms	34ms
70000   33ms   34ms   34ms   33ms   32ms     75000   34ms   34ms   33ms   34ms   33ms     80000   34ms   33ms   33ms   33ms   33ms     85000   34ms   33ms   33ms   33ms   33ms     90000   34ms   33ms   34ms   32ms   34ms     95000   34ms   33ms   33ms   33ms   33ms     4   33ms   33ms   33ms   33ms     33ms   33ms   33ms   33ms   33ms     30000   34ms   33ms   33ms   33ms     33ms   33ms   33ms   33ms   33ms	60000	34ms	34ms	34ms	33ms	33ms
75000   34ms   34ms   33ms   34ms   33ms     80000   34ms   33ms   33ms   33ms   33ms     85000   34ms   33ms   33ms   33ms   33ms   33ms     90000   34ms   33ms   34ms   32ms   34ms     100000   34ms   33ms   33ms   33ms   33ms     4   33ms   33ms   33ms   33ms     33ms   33ms   33ms   33ms   33ms	65000	34ms	33ms	33ms	33ms	33ms
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85000   34ms   33ms   34ms   34ms   34ms   34ms   34ms   34ms   33ms   33ms <t< th=""><th>75000</th><th>34ms</th><th>34ms</th><th>33ms</th><th>34ms</th><th>33ms</th></t<>	75000	34ms	34ms	33ms	34ms	33ms
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95000   34ms   33ms   34ms   32ms   34ms     100000   34ms   33ms   33ms   33ms   33ms     Array Size:   1000000	85000	34ms	33ms	33ms	33ms	33ms
100000   34ms   33ms   33ms   33ms   33ms     Array Size:   1000000	90000	33ms	33ms	33ms	33ms	33ms
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2 4 8 16 32 50000 511ms 313ms 295ms 308ms 238ms	100000	34ms	33ms	33ms	33ms	33ms
2 4 8 16 32 50000 511ms 313ms 295ms 308ms 238ms						
2 4 8 16 32 50000 511ms 313ms 295ms 308ms 238ms						
<b>50000</b> 511ms 313ms 295ms 308ms <b>238ms</b>	Array Size:					
		2	4	8	16	32
<b>100000</b> 313ms 267ms 243ms 243ms 240ms	50000	511ms	313ms	295ms	308ms	238ms
	100000	313ms	267ms	243ms	243ms	240ms

150000	347ms	280ms	241ms	241ms	240ms
200000	353ms	280ms	243ms	241ms	242ms
250000	347ms	279ms	245ms	242ms	240ms
300000	391ms	268ms	267ms	265ms	267ms
350000	395ms	267ms	268ms	267ms	268ms
400000	396ms	267ms	266ms	266ms	267ms
450000	392ms	268ms	267ms	268ms	267ms
500000	389ms	266ms	266ms	267ms	266ms
550000	376ms	374ms	371ms	373ms	373ms
600000	375ms	374ms	374ms	375ms	372ms
650000	376ms	373ms	375ms	373ms	373ms
700000	375ms	374ms	374ms	372ms	374ms
750000	375ms	375ms	375ms	373ms	373ms
800000	374ms	374ms	374ms	373ms	373ms
850000	372ms	373ms	373ms	374ms	373ms
900000	375ms	373ms	374ms	373ms	372ms
950000	374ms	374ms	375ms	373ms	373ms
1000000	372ms	375ms	371ms	374ms	372ms