Program Structures and Algorithms
Spring 2023(SEC –3)

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**Task:** Parallel Sorting

**Relationship Conclusion:**

- From the tests run we find that, as the size of the input array increases, the performance of the parallel merge sort improves.
- We find parallel sort works best when
  *(length of array) / $2^9$ +1 <= cutoff value < (length of array) /$2^4$ + 1.*
- Since the host machine has 8 cores, it seems to have worked consistently well from 4 – 8 threads. There are instances where 16 and 32 occasionally do well, but the overhead increases as the threads may spend more time waiting for each other. Managing the threads is an additional overhead and reduces performance.
- The performance of the parallel merge is highly dependent on the size of the input array, the cut off value for switching to sequential sort and the number of thread used for parallel sorting.

**Evidence to support that conclusion:**

| Size | Cut-off value | Threads | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 16 | 32 |
| 32768 | 33 | 47.77844 | 45.99284 | 57.41401 | 36.68063 | 54.1852 |
| | 65 | 17.17646 | 9.40345 | 16.39672 | 18.83177 | 20.53028 |
| | 129 | 8.377642 | 7.948158 | 9.07055 | 8.470338 | 9.604033 |
| | 257 | 5.295792 | 4.807708 | 5.068971 | 5.079525 | 5.365413 |
| | 513 | 3.726817 | 3.614029 | 3.776037 | 3.873975 | 3.902888 |
| | 1025 | 2.787254 | 3.216925 | 3.452087 | 3.222154 | 2.928921 |
| | 2049 | 2.565354 | 2.9672 | 4.638583 | 3.7192 | 2.534217 |
| | 4097 | 2.822912 | 2.789146 | 2.863667 | 4.171304 | 2.497071 |
| | 8193 | 3.517025 | 2.350129 | 3.670279 | 3.524588 | 2.963113 |
| | 16385 | 2.797488 | 1.80015 | 3.162846 | 2.042146 | 2.832417 |
| | 32769 | 2.836121 | 2.837842 | 2.829962 | 1.906612 | 3.054358 |

| Size | Cut-off value | Threads | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 16 | 32 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 1025 | 78.29353 | 80.09089 | 78.90559 | 77.57944 | 95.91934 |
| | 2049 | 47.56792 | 45.05024 | 54.04005 | 45.37641 | 56.91568 |
| | 4097 | 41.26229 | 41.7207 | 48.64243 | 47.40741 | 38.50228 |
| | 8193 | 36.39687 | 37.72699 | 43.0254 | 45.67245 | 36.55703 |
| | 16385 | 37.54335 | 38.62409 | 36.61676 | 36.51503 | 36.95573 |
| 1048576 | 32769 | 39.02963 | 39.3303 | 38.15051 | 42.30719 | 32.14715 |
| | 65537 | 43.69852 | 43.37497 | 42.15135 | 35.11809 | 32.28892 |
| | 131073 | 54.83293 | 45.81129 | 40.09797 | 33.75142 | 33.13891 |
| | 262145 | 59.14599 | 48.1234 | 37.42054 | 35.22664 | 36.18713 |
| | 524289 | 43.15455 | 43.19981 | 44.12469 | 45.24966 | 47.57439 |
| | 1048577 | 66.78743 | 66.9415 | 67.34577 | 69.35719 | 67.18683 |

| Size | Cut-off value | Threads | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 16 | 32 |
| | 2049 | 131.6477 | 119.3487 | 126.2775 | 129.8828 | 151.5295 |
| | 4097 | 92.55391 | 113.4295 | 93.24558 | 82.56407 | 81.4156 |
| | 8193 | 71.16703 | 85.64523 | 76.02942 | 77.99525 | 81.84653 |
| | 16385 | 72.85899 | 71.631 | 75.41515 | 74.91332 | 74.43244 |
| | 32769 | 73.02237 | 80.17005 | 75.92763 | 95.99372 | 80.20764 |
| 2097152 | 65537 | 80.70801 | 82.01894 | 78.44914 | 88.43422 | 71.19905 |
| | 131073 | 98.6689 | 95.2543 | 97.91977 | 77.25585 | 68.42556 |
| | 262145 | 102.5109 | 117.298 | 88.724 | 67.21209 | 68.86018 |
| | 524289 | 121.8072 | 98.33406 | 75.60064 | 79.4403 | 77.0712 |
| | 1048577 | 90.78186 | 93.77628 | 98.3787 | 98.67425 | 99.16264 |
| | 2097153 | 140.9911 | 140.0429 | 144.0419 | 144.824 | 147.3691 |

| Size | Cut-off value | Threads | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 16 | 32 |
| | 4097 | 222.1426 | 229.4767 | 214.7608 | 256.977 | 219.3078 |
| | 8193 | 153.8627 | 152.8425 | 171.0824 | 193.5773 | 162.6699 |
| 4194304 | 16385 | 145.7601 | 154.9321 | 154.6511 | 156.0789 | 160.2744 |
| | 32769 | 146.7211 | 156.8542 | 158.3745 | 158.3908 | 153.5819 |
| | 65537 | 154.6767 | 166.6599 | 181.1013 | 153.4659 | 162.5771 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 131073 | 178.9217 | 171.7509 | 174.7077 | 172.7314 | 137.0311 |
| | 262145 | 198.4115 | 218.3092 | 187.9169 | 158.5506 | 137.5918 |
| | 524289 | 209.2992 | 232.7925 | 193.4576 | 133.5776 | 146.7699 |
| | 1048577 | 259.5999 | 210.5898 | 158.9649 | 160.7802 | 159.1808 |
| | 2097153 | 195.6371 | 199.6034 | 202.7555 | 207.4354 | 201.5283 |
| | 4194305 | 294.9495 | 300.335 | 300.331 | 301.7693 | 298.4891 |