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**Program Structures & Algorithms**

**Fall 2021**

**Assignment No. 5**

**Tasks:**

1. A cutoff (defaults to, say, 1000) which you will update according to the first argument in the command line when running. It's your job to experiment and come up with a good value for this cutoff. If there are fewer elements to sort than the cutoff, then you should use the system sort instead.
2. Recursion depth or the number of available threads. Using this determination, you might decide on an ideal number (*t*) of separate threads (stick to powers of 2) and arrange for that number of partitions to be parallelized (by preventing recursion after the depth of *lg t* is reached).
3. An appropriate combination of these.

**Conclusion:**

Taking fixed array sized of length 2,000,000 & 4,000,000, with varying threadCount between 1,2,4,8,16,32,64 I have the following observations:

1. Performance is best for threadCount = 1 and worst for threadCount = 64.
2. For a threadCount of 1 & 2, the best cutoff range is between 0.08 and 0.5 percentage of array size, but for the most part is stable throughout.
3. For the remaining threadCount values the best cut off ranges between 0.26 and 0.5 percentage of the array size.
4. Performance has stability and a big jump for cut off range between 0.5 - 1.
5. Overall sorting time of larger array is more than the smaller, as would be expected.

Hence, I’d like to conclude that the ideal thread count value of 2-4 with a cut of range of 0.26 and 0.5 has the best performance for parallel sorting a large array.

Below is the data representation of conclusion stated above.

1. For Array size = 2,000,000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| cut off | threadCount = 1 | threadCount = 2 | threadCount = 4 | threadCount = 8 | threadCount = 16 | threadCount = 32 | threadCount = 64 |
| 0.02 | 1851 | 2029 | 1677 | 1675 | 1786 | 1852 | 1741 |
| 0.04 | 1589 | 1451 | 1605 | 1466 | 959 | 824 | 776 |
| 0.06 | 1645 | 1518 | 1501 | 1474 | 924 | 851 | 796 |
| 0.08 | 1838 | 1663 | 1594 | 1027 | 761 | 754 | 732 |
| 0.1 | 1902 | 1711 | 1574 | 907 | 734 | 735 | 784 |
| 0.12 | 1718 | 1734 | 1529 | 907 | 759 | 743 | 776 |
| 0.14 | 1995 | 1278 | 868 | 836 | 818 | 811 | 810 |
| 0.16 | 1789 | 1269 | 845 | 812 | 824 | 834 | 823 |
| 0.18 | 1789 | 1244 | 846 | 835 | 832 | 808 | 826 |
| 0.2 | 1945 | 1250 | 869 | 845 | 833 | 808 | 809 |
| 0.22 | 1852 | 1245 | 889 | 863 | 848 | 816 | 831 |
| 0.24 | 1811 | 1285 | 840 | 832 | 823 | 821 | 796 |
| 0.26 | 2060 | 1203 | 1201 | 1197 | 1193 | 1198 | 1137 |
| 0.28 | 2054 | 1201 | 1216 | 1219 | 1205 | 1211 | 1160 |
| 0.3 | 2080 | 1199 | 1191 | 1286 | 1212 | 1210 | 1162 |
| 0.32 | 2074 | 1212 | 1192 | 1192 | 1198 | 1204 | 1163 |
| 0.34 | 2038 | 1290 | 1204 | 1208 | 1212 | 1212 | 1156 |
| 0.36 | 2037 | 1528 | 1210 | 1245 | 1210 | 1210 | 1159 |
| 0.38 | 2055 | 1247 | 1219 | 1256 | 1209 | 1210 | 1158 |
| 0.4 | 2066 | 1183 | 1218 | 1200 | 1212 | 1209 | 1166 |
| 0.42 | 2058 | 1185 | 1244 | 1198 | 1212 | 1207 | 1148 |
| 0.44 | 2079 | 1203 | 1215 | 1190 | 1216 | 1211 | 1146 |
| 0.46 | 2067 | 1184 | 1215 | 1199 | 1211 | 1240 | 1168 |
| 0.48 | 2086 | 1185 | 1223 | 1201 | 1278 | 1198 | 1171 |
| 0.5 | 2086 | 1232 | 1199 | 1201 | 1199 | 1223 | 1160 |
| 0.52 | 2019 | 2129 | 1979 | 1941 | 1948 | 1970 | 1868 |
| 0.54 | 1962 | 2057 | 1961 | 1963 | 1935 | 1962 | 1863 |
| 0.56 | 1947 | 1963 | 1953 | 1932 | 1948 | 1965 | 1863 |
| 0.58 | 1969 | 1958 | 1950 | 1948 | 2030 | 1974 | 1864 |
| 0.6 | 1957 | 1946 | 1948 | 1942 | 1952 | 1963 | 1895 |
| 0.62 | 1981 | 1945 | 1953 | 1940 | 1934 | 1958 | 1871 |
| 0.64 | 1959 | 1949 | 1945 | 1957 | 1948 | 1961 | 1865 |
| 0.66 | 1961 | 1971 | 1949 | 1939 | 1939 | 1964 | 1900 |
| 0.68 | 1963 | 1955 | 2009 | 1964 | 1934 | 1965 | 1893 |
| 0.7 | 1953 | 1953 | 1992 | 1944 | 1957 | 1966 | 1914 |
| 0.72 | 1963 | 1942 | 1999 | 1938 | 1931 | 1969 | 1865 |
| 0.74 | 1954 | 1951 | 2028 | 1940 | 1933 | 1976 | 1895 |
| 0.76 | 1965 | 1947 | 1989 | 1945 | 1934 | 1959 | 1917 |
| 0.78 | 2083 | 1954 | 1999 | 1941 | 1930 | 1964 | 1906 |
| 0.8 | 1959 | 2021 | 1977 | 1940 | 1944 | 1962 | 1909 |
| 0.82 | 1985 | 1969 | 1977 | 1934 | 1958 | 1969 | 1891 |
| 0.84 | 2001 | 1951 | 1970 | 1938 | 1942 | 1962 | 1890 |
| 0.86 | 1964 | 1965 | 1972 | 1934 | 1936 | 1963 | 1890 |
| 0.88 | 1965 | 1948 | 1975 | 1939 | 1935 | 1975 | 1902 |
| 0.9 | 1961 | 1947 | 1979 | 1935 | 1932 | 2064 | 1902 |
| 0.92 | 1963 | 1954 | 1975 | 1940 | 1939 | 1959 | 1902 |
| 0.94 | 1962 | 1949 | 1981 | 1939 | 1941 | 2015 | 1906 |
| 0.96 | 1942 | 1941 | 1982 | 1952 | 1946 | 1961 | 1897 |
| 0.98 | 1942 | 1988 | 1973 | 1941 | 1992 | 1959 | 1896 |
| 1 | 1938 | 1952 | 1984 | 1936 | 1987 | 1965 | 1898 |

1. For Array size = 4,000,000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cut Off | threadCount = 1 | threadCount = 2 | threadCount = 4 | threadCount = 8 | threadCount = 16 | threadCount = 32 | threadCount = 64 |
| 0.02 | 3261 | 3284 | 3515 | 3534 | 3749 | 3303 | 3263 |
| 0.04 | 2820 | 2790 | 2798 | 2942 | 2769 | 1606 | 1651 |
| 0.06 | 2880 | 2788 | 2686 | 2725 | 2765 | 1678 | 1561 |
| 0.08 | 3526 | 3132 | 3090 | 2869 | 1840 | 1508 | 1425 |
| 0.1 | 3162 | 3171 | 3119 | 2856 | 1834 | 1577 | 1444 |
| 0.12 | 3152 | 3184 | 3198 | 2746 | 1796 | 1603 | 1440 |
| 0.14 | 3823 | 3365 | 3264 | 1823 | 1518 | 1506 | 1463 |
| 0.16 | 3649 | 3272 | 3405 | 1738 | 1511 | 1509 | 1411 |
| 0.18 | 3768 | 3376 | 3264 | 1698 | 1543 | 1518 | 1399 |
| 0.2 | 3483 | 3399 | 3370 | 1695 | 1549 | 1512 | 1591 |
| 0.22 | 3876 | 3290 | 3143 | 1719 | 1535 | 1506 | 1407 |
| 0.24 | 3626 | 3303 | 3290 | 1710 | 1599 | 1514 | 1394 |
| 0.26 | 4134 | 2599 | 1792 | 1625 | 1812 | 1730 | 1609 |
| 0.28 | 4108 | 2616 | 1781 | 1675 | 1779 | 1779 | 1591 |
| 0.3 | 3941 | 2535 | 1809 | 1621 | 2002 | 1766 | 1598 |
| 0.32 | 4005 | 2533 | 1792 | 1626 | 1758 | 1864 | 1590 |
| 0.34 | 3955 | 2591 | 1792 | 1630 | 1742 | 1729 | 1587 |
| 0.36 | 4314 | 2527 | 1789 | 1623 | 1798 | 1706 | 1614 |
| 0.38 | 4184 | 2594 | 1810 | 1629 | 1771 | 1774 | 1595 |
| 0.4 | 3914 | 2525 | 1740 | 1634 | 1745 | 1777 | 1594 |
| 0.42 | 4132 | 2518 | 1731 | 1630 | 1735 | 1811 | 1592 |
| 0.44 | 4032 | 2540 | 1848 | 1626 | 1819 | 1779 | 1594 |
| 0.46 | 4170 | 2554 | 1752 | 1631 | 1848 | 1808 | 1598 |
| 0.48 | 3883 | 2494 | 1740 | 1634 | 1804 | 1763 | 1606 |
| 0.5 | 4328 | 2476 | 1767 | 1632 | 1741 | 1784 | 1595 |
| 0.52 | 4336 | 2336 | 2496 | 2418 | 2526 | 2672 | 2401 |
| 0.54 | 4330 | 2343 | 2520 | 2438 | 2549 | 2695 | 2394 |
| 0.56 | 4370 | 2344 | 2519 | 2443 | 2546 | 2482 | 2458 |
| 0.58 | 4337 | 2335 | 2524 | 2448 | 2540 | 2496 | 2452 |
| 0.6 | 4360 | 2338 | 2541 | 2452 | 2533 | 2481 | 2417 |
| 0.62 | 4325 | 2333 | 2527 | 2441 | 2555 | 2460 | 2425 |
| 0.64 | 4343 | 2339 | 2530 | 2433 | 2689 | 2489 | 2453 |
| 0.66 | 4266 | 2354 | 2517 | 2459 | 2560 | 2473 | 2439 |
| 0.68 | 4277 | 2375 | 2613 | 2431 | 2602 | 2476 | 2438 |
| 0.7 | 4346 | 2350 | 2558 | 2441 | 2580 | 2462 | 2571 |
| 0.72 | 4296 | 2338 | 2613 | 2429 | 2610 | 2487 | 2496 |
| 0.74 | 4288 | 2363 | 2539 | 2427 | 2595 | 2562 | 2474 |
| 0.76 | 4337 | 2342 | 2525 | 2462 | 2577 | 2523 | 2471 |
| 0.78 | 4416 | 2344 | 2588 | 2446 | 2575 | 2507 | 2504 |
| 0.8 | 4422 | 2368 | 2512 | 2450 | 2646 | 2468 | 2575 |
| 0.82 | 4381 | 2380 | 2542 | 2454 | 2605 | 2622 | 2468 |
| 0.84 | 4378 | 2403 | 2528 | 2432 | 2583 | 2630 | 2570 |
| 0.86 | 4306 | 2392 | 2513 | 2438 | 2551 | 2487 | 2459 |
| 0.88 | 4398 | 2391 | 2519 | 2452 | 2614 | 2454 | 2586 |
| 0.9 | 4404 | 2389 | 2552 | 2427 | 2547 | 2470 | 2461 |
| 0.92 | 4396 | 2339 | 2577 | 2455 | 2548 | 2513 | 2465 |
| 0.94 | 4418 | 2434 | 2540 | 2453 | 2556 | 2467 | 2539 |
| 0.96 | 4271 | 2396 | 2572 | 2438 | 2612 | 2498 | 2511 |
| 0.98 | 4291 | 2440 | 2538 | 2435 | 2635 | 2586 | 2497 |
| 1 | 4242 | 2368 | 2518 | 2453 | 2569 | 2549 | 2491 |