Assignment 6

Student: Tung Huynh (8007954)

# Problem 1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Method** | **Blocking** | | | | | |
| **Destination** | **2** | **4** | **8** | **16** | **32** | **56** |
| **Size** |
| 1 | 0.000054 | 0.000280 | 0.000118 | 0.002803 | 0.000139 | 0.000119 |
| 0.000060 | 0.000285 | 0.003739 | 0.000122 | 0.000159 | 0.000131 |
| 0.003766 | 0.000326 | 0.000160 | 0.000156 | 0.000187 | 0.000168 |
| 10 | 0.000087 | 0.000217 | 0.000078 | 0.000075 | 0.000075 | 0.000094 |
| 0.000058 | 0.000287 | 0.000124 | 0.006322 | 0.000141 | 0.000122 |
| 0.048367 | 0.000252 | 0.000094 | 0.000090 | 0.000089 | 0.000111 |
| 100 | 0.047875 | 0.000253 | 0.000114 | 0.000112 | 0.004606 | 0.000123 |
| 0.118281 | 0.000208 | 0.000081 | 0.099646 | 0.000039 | 0.000044 |
| 0.000057 | 0.000025 | 0.007986 | 0.000029 | 0.024645 | 0.000117 |
| 1000 | 0.000076 | 0.000214 | 0.000089 | 0.000084 | 0.000085 | 0.000105 |
| 0.045412 | 0.000029 | 0.000033 | 0.000042 | 0.000034 | 0.000042 |
| 0.088650 | 0.000224 | 0.007507 | 0.000043 | 0.000034 | 0.000040 |
| 10000 | 0.000168 | 0.000139 | 0.033840 | 0.000158 | 0.000140 | 0.000162 |
| 0.000165 | 0.000140 | 0.047339 | 0.000161 | 0.000149 | 0.000161 |
| 0.000952 | 0.000135 | 0.000166 | 0.000170 | 0.000153 | 0.000172 |
| 100000 | 0.003434 | 0.000389 | 0.000244 | 0.000207 | 0.000222 | 0.000227 |
| 0.000157 | 0.000306 | 0.000184 | 0.002787 | 0.000170 | 0.000186 |
| 0.044598 | 0.003402 | 0.000182 | 0.000175 | 0.003459 | 0.000190 |
| 1000000 | 0.001222 | 0.001071 | 0.001059 | 0.042618 | 0.001105 | 0.001180 |
| 0.001320 | 0.001209 | 0.001216 | 0.001476 | 0.001227 | 0.001415 |
| 0.001294 | 0.001158 | 0.001182 | 0.001464 | 0.001209 | 0.001388 |
| 10000000 | 0.189770 | 0.010275 | 0.094923 | 0.103617 | 0.100486 | 0.193524 |
| 0.116997 | 0.093647 | 0.099266 | 0.103271 | 0.099617 | 0.101357 |
| 0.196396 | 0.101417 | 0.200419 | 0.193557 | 0.102455 | 0.105121 |
| 100000000 | 2.287473 | 1.906294 | 1.596156 | 2.199299 | 1.403229 | 2.000104 |
| 1.597225 | 1.701684 | 1.597434 | 2.397482 | 1.604382 | 2.302202 |
| 2.198630 | 2.101015 | 2.401341 | 2.302087 | 2.100082 | 2.296497 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Method** | **Non-Blocking** | | | | | |
| **Destination** | **2** | **4** | **8** | **16** | **32** | **56** |
| **Size** |
| 1 | 0.000033 | 0.000005 | 0.000005 | 0.000007 | 0.000006 | 0.000005 |
| 0.000029 | 0.000006 | 0.000006 | 0.000005 | 0.000005 | 0.000005 |
| 0.000055 | 0.000006 | 0.000009 | 0.000004 | 0.000005 | 0.000005 |
| 10 | 0.000042 | 0.000007 | 0.000006 | 0.000007 | 0.000007 | 0.000008 |
| 0.000031 | 0.000003 | 0.000006 | 0.000004 | 0.000005 | 0.000006 |
| 0.000027 | 0.000003 | 0.000007 | 0.000004 | 0.000005 | 0.000008 |
| 100 | 0.000026 | 0.000003 | 0.000004 | 0.000006 | 0.000005 | 0.000005 |
| 0.000029 | 0.000006 | 0.000002 | 0.000005 | 0.000005 | 0.000005 |
| 0.000031 | 0.000003 | 0.000002 | 0.000003 | 0.000005 | 0.000007 |
| 1000 | 0.000033 | 0.000007 | 0.000007 | 0.000008 | 0.000006 | 0.000007 |
| 0.000008 | 0.000005 | 0.000007 | 0.000006 | 0.000006 | 0.000006 |
| 0.000030 | 0.000007 | 0.000003 | 0.000005 | 0.000013 | 0.000006 |
| 10000 | 0.000086 | 0.000058 | 0.000057 | 0.000060 | 0.000061 | 0.000060 |
| 0.000087 | 0.000062 | 0.000059 | 0.000060 | 0.000062 | 0.000060 |
| 0.000099 | 0.000070 | 0.000067 | 0.000069 | 0.000071 | 0.000073 |
| 100000 | 0.000105 | 0.000076 | 0.000074 | 0.000084 | 0.000086 | 0.000081 |
| 0.000101 | 0.000072 | 0.000073 | 0.000073 | 0.000072 | 0.000074 |
| 0.000102 | 0.000073 | 0.000073 | 0.000073 | 0.000075 | 0.000081 |
| 1000000 | 0.000878 | 0.000828 | 0.000128 | 0.000956 | 0.000126 | 0.000156 |
| 0.000838 | 0.000779 | 0.000813 | 0.000873 | 0.000811 | 0.000898 |
| 0.000990 | 0.000959 | 0.000987 | 0.000228 | 0.000174 | 0.000213 |
| 10000000 | 0.194612 | 0.000127 | 0.000825 | 0.000921 | 0.000122 | 0.000146 |
| 0.004971 | 0.000143 | 0.000136 | 0.000167 | 0.000136 | 0.000167 |
| 0.007803 | 0.000914 | 0.000890 | 0.000966 | 0.000882 | 0.001036 |
| 100000000 | 0.797828 | 0.000207 | 0.000168 | 0.000956 | 0.000123 | 0.000124 |
| 1.191903 | 0.000359 | 0.002220 | 0.001337 | 0.000252 | 0.000245 |
| 1.101764 | 0.001102 | 0.000970 | 0.087624 | 0.000210 | 0.000200 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Method** | **Blocking - Avg Time** | | | | | |
| **Pair/Msg Size** | **2** | **4** | **8** | **16** | **32** | **56** |
|
| 1 | 0.001293 | 0.000297 | 0.001339 | 0.001027 | 0.000162 | 0.000139 |
|
|
| 10 | 0.016171 | 0.000252 | 0.000099 | 0.002162 | 0.000102 | 0.000109 |
|
|
| 100 | 0.055404 | 0.000162 | 0.002727 | 0.033262 | 0.009763 | 0.000095 |
|
|
| 1000 | 0.044713 | 0.000156 | 0.002543 | 0.000056 | 0.000051 | 0.000062 |
|
|
| 10000 | 0.000428 | 0.000138 | 0.027115 | 0.000163 | 0.000147 | 0.000165 |
|
|
| 100000 | 0.016063 | 0.001366 | 0.000203 | 0.001056 | 0.001284 | 0.000201 |
|
|
| 1000000 | 0.001279 | 0.001146 | 0.001152 | 0.015186 | 0.001180 | 0.001328 |
|
|
| 10000000 | 0.167721 | 0.068446 | 0.131536 | 0.133482 | 0.100853 | 0.133334 |
|
|
| 100000000 | 2.027776 | 1.902998 | 1.864977 | 2.299623 | 1.702564 | 2.199601 |
|
|

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Method** | **Non-Blocking - Avg Time** | | | | | |
| **Pair/Msg Size** | **2** | **4** | **8** | **16** | **32** | **56** |
|
| 1 | 0.000039 | 0.000006 | 0.000007 | 0.000005 | 0.000005 | 0.000005 |
|
|
| 10 | 0.000033 | 0.000004 | 0.000006 | 0.000005 | 0.000006 | 0.000007 |
|
|
| 100 | 0.000029 | 0.000004 | 0.000003 | 0.000005 | 0.000005 | 0.000006 |
|
|
| 1000 | 0.000024 | 0.000006 | 0.000006 | 0.000006 | 0.000008 | 0.000006 |
|
|
| 10000 | 0.000091 | 0.000063 | 0.000061 | 0.000063 | 0.000065 | 0.000064 |
|
|
| 100000 | 0.000103 | 0.000074 | 0.000073 | 0.000077 | 0.000078 | 0.000079 |
|
|
| 1000000 | 0.000902 | 0.000855 | 0.000643 | 0.000686 | 0.000370 | 0.000422 |
|
|
| 10000000 | 0.069129 | 0.000395 | 0.000617 | 0.000685 | 0.000380 | 0.000450 |
|
|
| 100000000 | 1.030498 | 0.000556 | 0.001119 | 0.029972 | 0.000195 | 0.000190 |
|
|

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Method** | | **Blocking - Bandwidth (MB/s)** | | | | | | | | | | | |
| **Pair/Msg Size** | | **2** | | **4** | | **8** | | **16** | **32** | | **56** | | |
|
| 1 | | 0.0008 | | 0.0034 | | 0.0007 | | 0.0010 | 0.0062 | | 0.0072 | | |
|
|
| 10 | | 0.0006 | | 0.0397 | | 0.1014 | | 0.0046 | 0.0984 | | 0.0917 | | |
|
|
| 100 | | 0.0018 | | 0.6173 | | 0.0367 | | 0.0030 | 0.0102 | | 1.0563 | | |
|
|
| 1000 | | 0.0224 | | 6.4240 | | 0.3932 | | 17.7515 | 19.6078 | | 16.0428 | | |
|
|
| 10000 | | 23.3463 | | 72.4638 | | 0.3688 | | 61.3497 | 67.8733 | | 60.6061 | | |
|
|
| 100000 | | 6.2255 | | 73.2243 | | 491.8033 | | 94.6671 | 77.9018 | | 497.5124 | | |
|
|
| 1000000 | | 782.0647 | | 872.6003 | | 867.8045 | | 65.8501 | 847.2183 | | 753.2011 | | |
|
|
| 10000000 | | 59.6228 | | 146.0999 | | 76.0248 | | 74.9167 | 99.1545 | | 74.9996 | | |
|
|
| 100000000 | | 49.3151 | | 52.5487 | | 53.6200 | | 43.4854 | 58.7349 | | 45.4628 | | |
|
|
| **Method** | **Non-Blocking - Bandwidth (MB/s)** | | | | | | | | | | | |
| **Pair/Msg Size** | **2** | | **4** | | **8** | | **16** | | | **32** | | **56** |
|
| 1 | 0.0256 | | 0.1765 | | 0.1500 | | 0.1875 | | | 0.1875 | | 0.2000 |
|
|
| 10 | 0.3000 | | 2.3077 | | 1.5789 | | 2.0000 | | | 1.7647 | | 1.3636 |
|
|
| 100 | 3.4884 | | 25.0000 | | 37.5000 | | 21.4286 | | | 20.0000 | | 17.6471 |
|
|
| 1000 | 42.2535 | | 157.8947 | | 176.4706 | | 157.8947 | | | 120.0000 | | 157.8947 |
|
|
| 10000 | 110.2941 | | 157.8947 | | 163.9344 | | 158.7302 | | | 154.6392 | | 155.4404 |
|
|
| 100000 | 974.0260 | | 1357.4661 | | 1363.6364 | | 1304.3478 | | | 1287.5536 | | 1271.1864 |
|
|
| 1000000 | 1108.6475 | | 1169.1348 | | 1556.0166 | | 1458.4346 | | | 2700.2700 | | 2367.7979 |
|
|
| 10000000 | 144.66 | | 25337.84 | | 16207.46 | | 14605.65 | | | 26315.79 | | 22238.70 |
|
|
| 100000000 | 97.04 | | 179856.12 | | 89338.89 | | 3336.41 | | | 512820.51 | | 527240.77 |
|
|

# Problem 2

# Problem 3

|  |
| --- |
| Run for 4 procs  Global rank= 0, Group rank= 0, recvbuf= 1  Global rank= 1, Group rank= 1, recvbuf= 1  Global rank= 2, Group rank= 0, recvbuf= 5  Global rank= 3, Group rank= 1, recvbuf= 5  -----------------------------------------  Run for 8 procs  Global rank= 0, Group rank= 0, recvbuf= 6  Global rank= 1, Group rank= 1, recvbuf= 6  Global rank= 2, Group rank= 2, recvbuf= 6  Global rank= 3, Group rank= 3, recvbuf= 6  Global rank= 4, Group rank= 0, recvbuf= 22  Global rank= 5, Group rank= 1, recvbuf= 22  Global rank= 6, Group rank= 2, recvbuf= 22  Global rank= 7, Group rank= 3, recvbuf= 22  -----------------------------------------  Run for 16 procs  Global rank= 0, Group rank= 0, recvbuf= 28  Global rank= 1, Group rank= 1, recvbuf= 28  Global rank= 2, Group rank= 2, recvbuf= 28  Global rank= 3, Group rank= 3, recvbuf= 28  Global rank= 4, Group rank= 4, recvbuf= 28  Global rank= 5, Group rank= 5, recvbuf= 28  Global rank= 6, Group rank= 6, recvbuf= 28  Global rank= 7, Group rank= 7, recvbuf= 28  Global rank= 8, Group rank= 0, recvbuf= 92  Global rank= 9, Group rank= 1, recvbuf= 92  Global rank= 10, Group rank= 2, recvbuf= 92  Global rank= 11, Group rank= 3, recvbuf= 92  Global rank= 12, Group rank= 4, recvbuf= 92  Global rank= 13, Group rank= 5, recvbuf= 92  Global rank= 14, Group rank= 6, recvbuf= 92  Global rank= 15, Group rank= 7, recvbuf= 92  -----------------------------------------  Run for 32 procs  Global rank= 0, Group rank= 0, recvbuf= 120  Global rank= 4, Group rank= 4, recvbuf= 120  Global rank= 12, Group rank= 12, recvbuf= 120  Global rank= 16, Group rank= 0, recvbuf= 376  Global rank= 20, Group rank= 4, recvbuf= 376  Global rank= 24, Group rank= 8, recvbuf= 376  Global rank= 28, Group rank= 12, recvbuf= 376  Global rank= 1, Group rank= 1, recvbuf= 120  Global rank= 2, Group rank= 2, recvbuf= 120  Global rank= 3, Group rank= 3, recvbuf= 120  Global rank= 5, Group rank= 5, recvbuf= 120  Global rank= 6, Group rank= 6, recvbuf= 120  Global rank= 7, Group rank= 7, recvbuf= 120  Global rank= 8, Group rank= 8, recvbuf= 120  Global rank= 9, Group rank= 9, recvbuf= 120  Global rank= 10, Group rank= 10, recvbuf= 120  Global rank= 11, Group rank= 11, recvbuf= 120  Global rank= 13, Group rank= 13, recvbuf= 120  Global rank= 14, Group rank= 14, recvbuf= 120  Global rank= 15, Group rank= 15, recvbuf= 120  Global rank= 19, Group rank= 3, recvbuf= 376  Global rank= 21, Group rank= 5, recvbuf= 376  Global rank= 23, Group rank= 7, recvbuf= 376  Global rank= 27, Group rank= 11, recvbuf= 376  Global rank= 29, Group rank= 13, recvbuf= 376  Global rank= 31, Group rank= 15, recvbuf= 376  Global rank= 17, Group rank= 1, recvbuf= 376  Global rank= 18, Group rank= 2, recvbuf= 376  Global rank= 22, Group rank= 6, recvbuf= 376  Global rank= 25, Group rank= 9, recvbuf= 376  Global rank= 26, Group rank= 10, recvbuf= 376  Global rank= 30, Group rank= 14, recvbuf= 376  -----------------------------------------  Run for 64 procs  Global rank= 0, Group rank= 0, recvbuf= 378  Global rank= 1, Group rank= 1, recvbuf= 378  Global rank= 2, Group rank= 2, recvbuf= 378  Global rank= 3, Group rank= 3, recvbuf= 378  Global rank= 4, Group rank= 4, recvbuf= 378  Global rank= 5, Group rank= 5, recvbuf= 378  Global rank= 6, Group rank= 6, recvbuf= 378  Global rank= 7, Group rank= 7, recvbuf= 378  Global rank= 9, Group rank= 9, recvbuf= 378  Global rank= 10, Group rank= 10, recvbuf= 378  Global rank= 11, Group rank= 11, recvbuf= 378  Global rank= 13, Group rank= 13, recvbuf= 378  Global rank= 14, Group rank= 14, recvbuf= 378  Global rank= 15, Group rank= 15, recvbuf= 378  Global rank= 16, Group rank= 16, recvbuf= 378  Global rank= 17, Group rank= 17, recvbuf= 378  Global rank= 18, Group rank= 18, recvbuf= 378  Global rank= 19, Group rank= 19, recvbuf= 378  Global rank= 20, Group rank= 20, recvbuf= 378  Global rank= 21, Group rank= 21, recvbuf= 378  Global rank= 22, Group rank= 22, recvbuf= 378  Global rank= 23, Group rank= 23, recvbuf= 378  Global rank= 24, Group rank= 24, recvbuf= 378  Global rank= 25, Group rank= 25, recvbuf= 378  Global rank= 26, Group rank= 26, recvbuf= 378  Global rank= 27, Group rank= 27, recvbuf= 378  Global rank= 8, Group rank= 8, recvbuf= 378  Global rank= 12, Group rank= 12, recvbuf= 378  Global rank= 28, Group rank= 0, recvbuf= 1162  Global rank= 29, Group rank= 1, recvbuf= 1162  Global rank= 30, Group rank= 2, recvbuf= 1162  Global rank= 31, Group rank= 3, recvbuf= 1162  Global rank= 32, Group rank= 4, recvbuf= 1162  Global rank= 33, Group rank= 5, recvbuf= 1162  Global rank= 35, Group rank= 7, recvbuf= 1162  Global rank= 38, Group rank= 10, recvbuf= 1162  Global rank= 39, Group rank= 11, recvbuf= 1162  Global rank= 40, Group rank= 12, recvbuf= 1162  Global rank= 41, Group rank= 13, recvbuf= 1162  Global rank= 42, Group rank= 14, recvbuf= 1162  Global rank= 43, Group rank= 15, recvbuf= 1162  Global rank= 44, Group rank= 16, recvbuf= 1162  Global rank= 45, Group rank= 17, recvbuf= 1162  Global rank= 46, Group rank= 18, recvbuf= 1162  Global rank= 47, Group rank= 19, recvbuf= 1162  Global rank= 48, Group rank= 20, recvbuf= 1162  Global rank= 49, Group rank= 21, recvbuf= 1162  Global rank= 50, Group rank= 22, recvbuf= 1162  Global rank= 51, Group rank= 23, recvbuf= 1162  Global rank= 52, Group rank= 24, recvbuf= 1162  Global rank= 53, Group rank= 25, recvbuf= 1162  Global rank= 54, Group rank= 26, recvbuf= 1162  Global rank= 55, Group rank= 27, recvbuf= 1162  Global rank= 34, Group rank= 6, recvbuf= 1162  Global rank= 36, Group rank= 8, recvbuf= 1162  Global rank= 37, Group rank= 9, recvbuf= 1162  ----------------------------------------- |

# Problem 4

<https://www.codeproject.com/KB/threads/Parallel_Quicksort/Parallel_Quick_sort_without_merge.pdf>