CS525 Parallel Computing HW4

Q1.

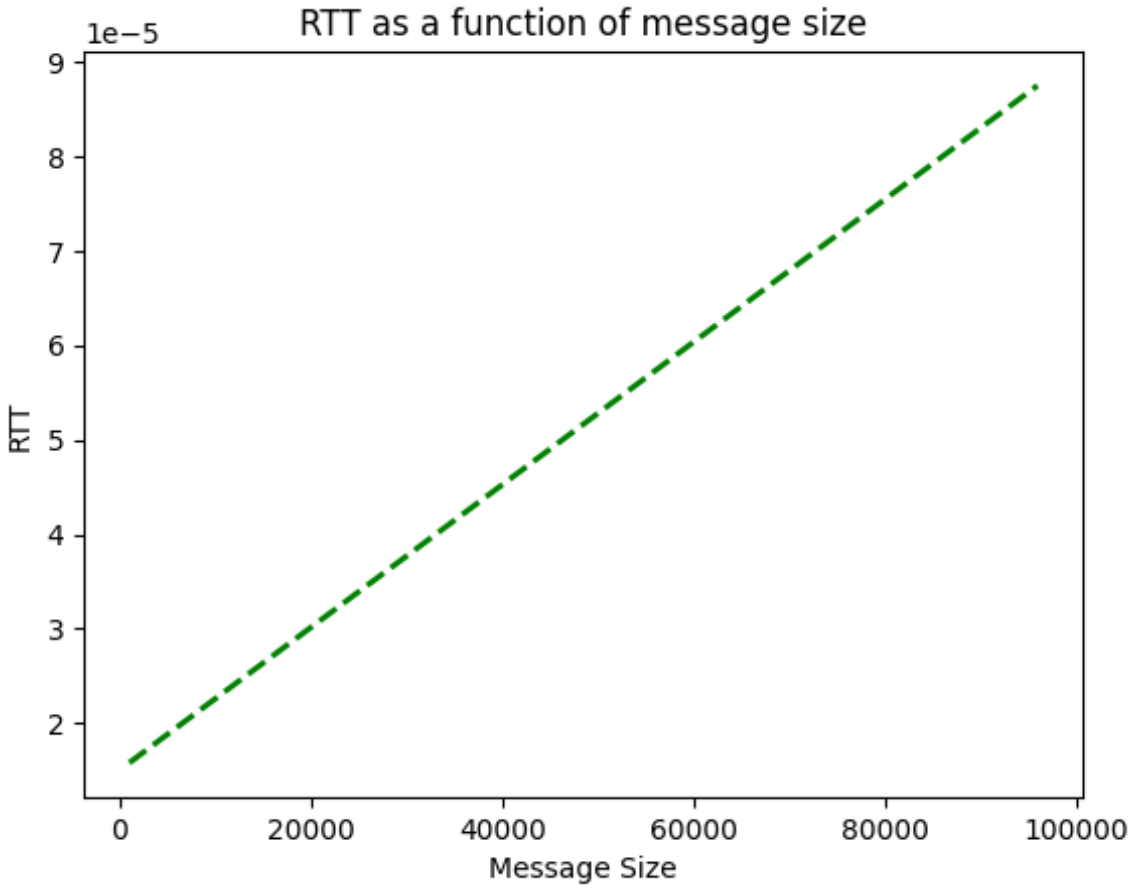
The following line estimates startup time ts and per-word transfer time tw by fitting the line RTT = 2 ts + 2 tw * m, which gives the tw value as 3.771923684210527e-10 sec/bytes and ts value as 7.532002631578949e-06 sec.

I have used python numpy's polyfit library to calculate the slope and intercept of the line RTT = 2 ts + 2 tw * m,

where RTT is calculated in the code as (end_time – start_time)/number of ping-pongs,

and m is the message size.

Upon using polyfit, we get slope which is 2*tw and intercept which is 2*ts. Dividing the slope and intercept by 2, we get tw and ts values which are 3.771923684210527e-10 sec/bytes 7.532002631578949e-06 sec respectively.



Output of code:

RTT for length 1000 is:0.000005 seconds Communication Time:0.0000026180 seconds

RTT for length 6000 is:0.0000123592 seconds Communication Time:0.0000061796 seconds

RTT for length 11000 is:0.0000149062 seconds Communication Time:0.0000074531 seconds

RTT for length 16000 is:0.0000181036 seconds Communication Time:0.0000090518 seconds

RTT for length 21000 is:0.0000190130 seconds Communication Time:0.0000095065 seconds

RTT for length 26000 is:0.0000220637 seconds Communication Time:0.0000110319 seconds

RTT for length 31000 is:0.0000248405 seconds Communication Time:0.0000124203 seconds

RTT for length 36000 is:0.0000254321 seconds Communication Time:0.0000127160 seconds

RTT for length 41000 is:0.0000285267 seconds Communication Time:0.0000142634 seconds

RTT for length 46000 is:0.0000305654 seconds Communication Time:0.0000152827 seconds

RTT for length 51000 is:0.0000323938 seconds Communication Time:0.0000161969 seconds

RTT for length 56000 is:0.0000345351 seconds Communication Time:0.0000172676 seconds

RTT for length 61000 is:0.0000371458 seconds Communication Time:0.0000185729 seconds

RTT for length 66000 is:0.0000390331 seconds Communication Time:0.0000195165 seconds

RTT for length 71000 is:0.0000412671 seconds Communication Time:0.0000206336 seconds

RTT for length 76000 is:0.0000428708 seconds Communication Time:0.0000214354 seconds

RTT for length 81000 is:0.0000458480 seconds Communication Time:0.0000229240 seconds

RTT for length 86000 is:0.0000475934 seconds Communication Time:0.0000237967 seconds

RTT for length 91000 is:0.0000499694 seconds Communication Time:0.0000249847 seconds

RTT for length 96000 is:0.0000510303 seconds Communication Time:0.0000255151 seconds

Execute the code:

Code will be found inside hw4/question1/ folder

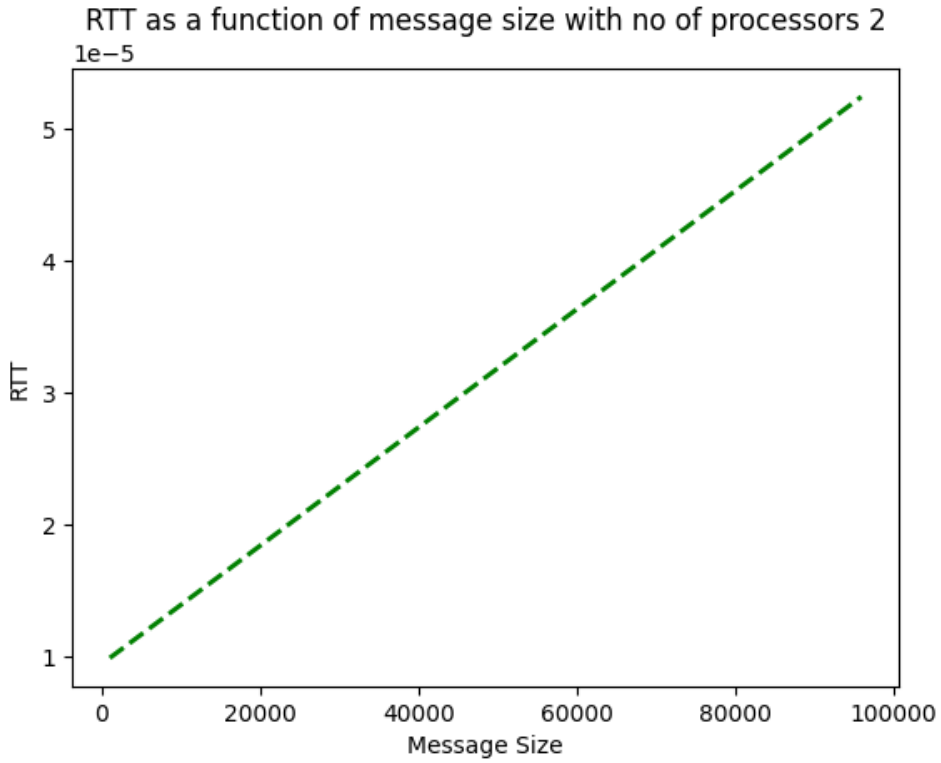
Compile: mpic++ -o main main.cpp

Execute: mpirun -np 2 ./main

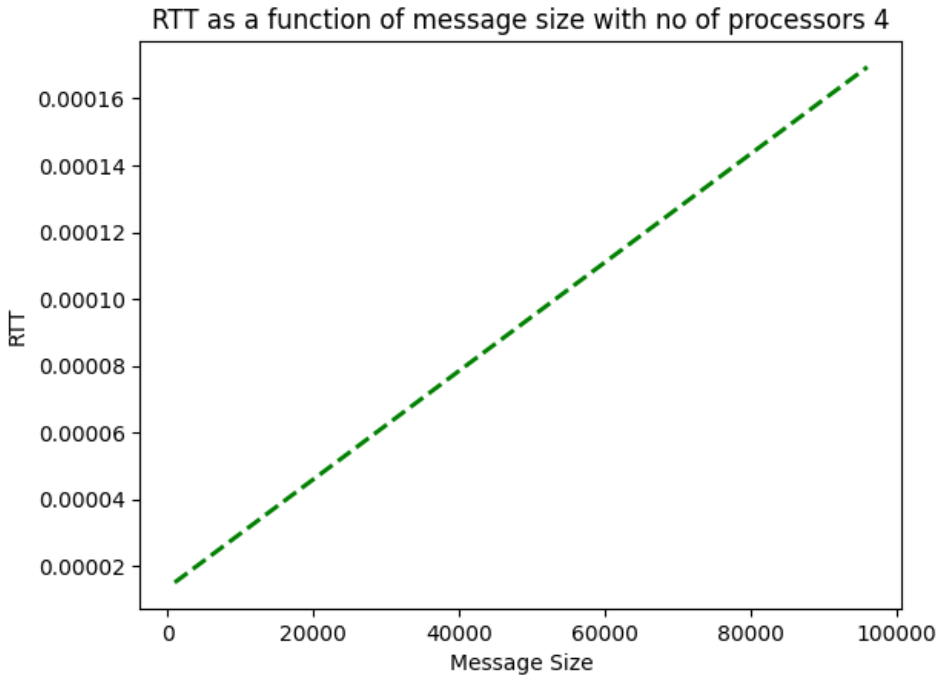
Q2. The following line estimates startup time ts and per-word transfer time tw by fitting the line

RTT = 2 ts + 2 tw * m for different values of p (2,4,8,16,32).

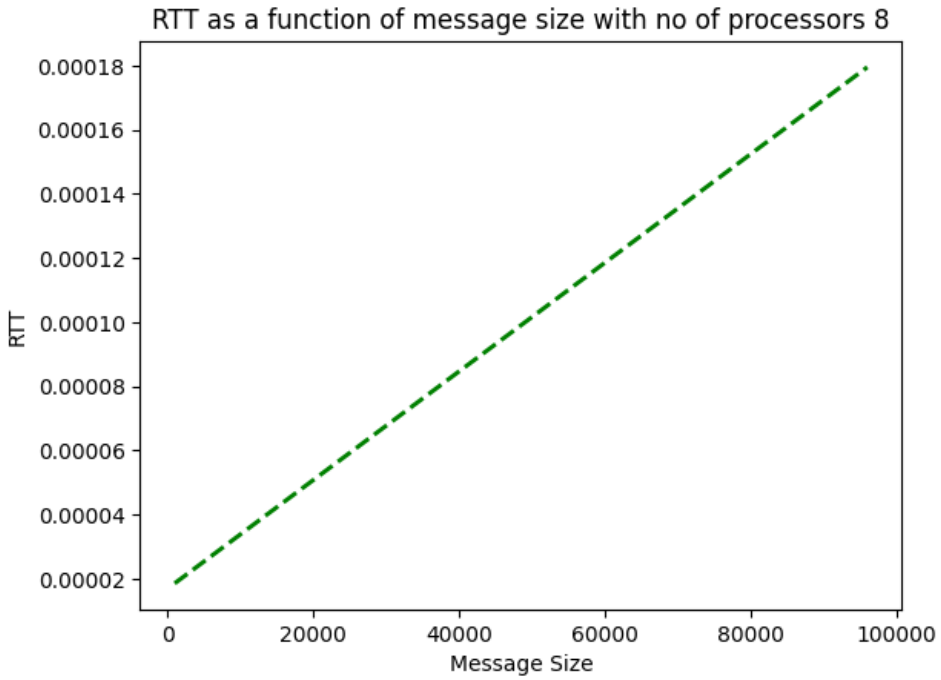
Fitting the line RTT = 2 ts + 2 tw * m for p = 2 gives us tw value as 2.2390759398496235e-10 sec/bytes and ts value as 4.702911691729323e-06 sec.



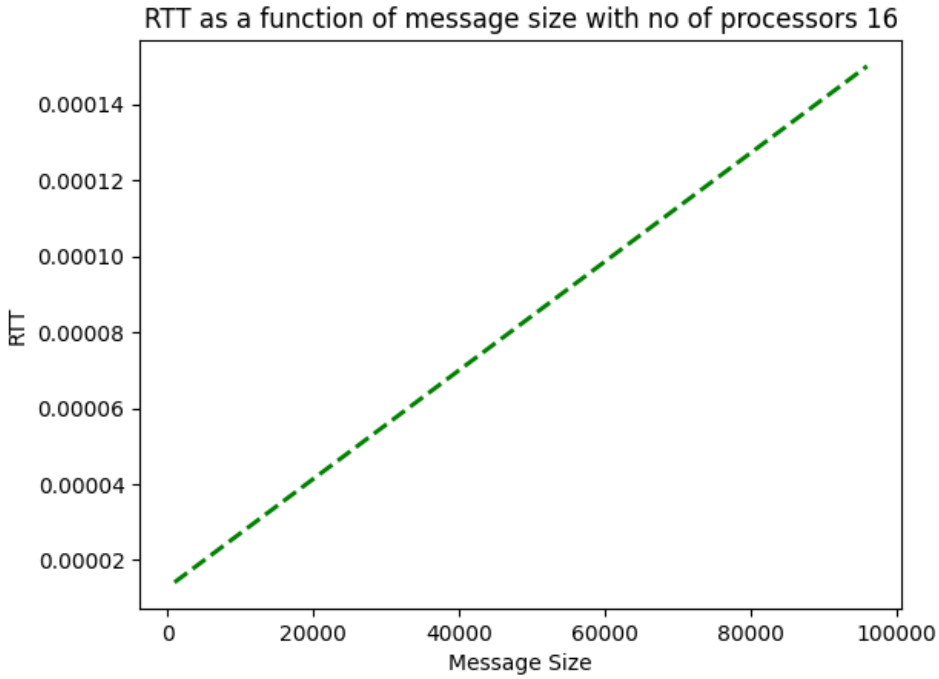
Fitting the line RTT = 2 ts + 2 tw * m for p = 4 gives us tw value as 8.12168052631579e-10 sec/bytes and ts value as 6.749821947368422e-06 sec



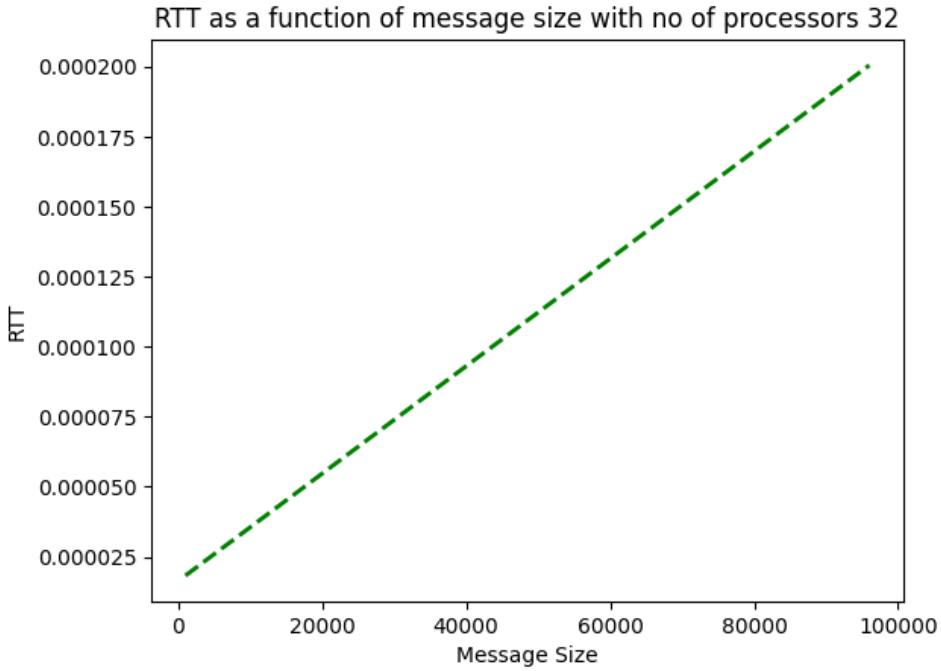
Fitting the line RTT = 2 ts + 2 tw * m for p = 8 gives us tw value as 8.470814210526314e-10 sec/bytes and ts value as 8.449358578947364e-06 sec.



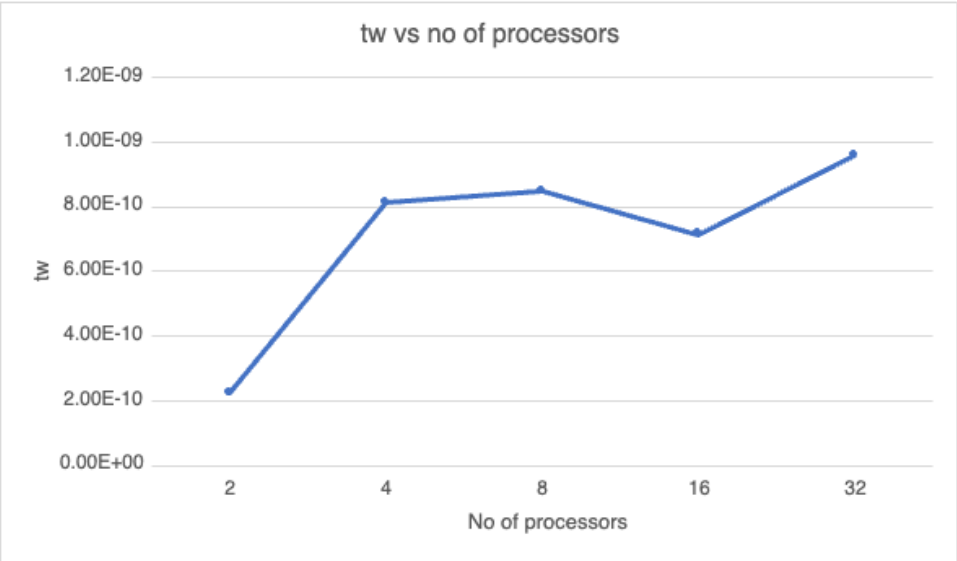
Fitting the line RTT = 2 ts + 2 tw * m for p = 16 gives us tw value as 7.149322556390978e-10 sec/bytes and ts value as 6.366440601503754e-06 sec.



Fitting the line RTT = 2 ts + 2 tw * m for p = 16 gives us tw value as 9.586498571428574e-10 sec/bytesand ts value as 8.17681942857142e-06 sec.



Plotted the dependence of t_w on p



Output of the code:

mc19 146 $ mpirun -np 2 ./test2

No protocol specified

RTT for length 1000 is:0.000005 seconds Communication Time:0.0000026180 seconds

RTT for length 6000 is:0.0000123592 seconds Communication Time:0.0000061796 seconds

RTT for length 11000 is:0.0000149062 seconds Communication Time:0.0000074531 seconds

RTT for length 16000 is:0.0000181036 seconds Communication Time:0.0000090518 seconds

RTT for length 21000 is:0.0000190130 seconds Communication Time:0.0000095065 seconds

RTT for length 26000 is:0.0000220637 seconds Communication Time:0.0000110319 seconds

RTT for length 31000 is:0.0000248405 seconds Communication Time:0.0000124203 seconds

RTT for length 36000 is:0.0000254321 seconds Communication Time:0.0000127160 seconds

RTT for length 41000 is:0.0000285267 seconds Communication Time:0.0000142634 seconds

RTT for length 46000 is:0.0000305654 seconds Communication Time:0.0000152827 seconds

RTT for length 51000 is:0.0000323938 seconds Communication Time:0.0000161969 seconds

RTT for length 56000 is:0.0000345351 seconds Communication Time:0.0000172676 seconds

RTT for length 61000 is:0.0000371458 seconds Communication Time:0.0000185729 seconds

RTT for length 66000 is:0.0000390331 seconds Communication Time:0.0000195165 seconds

RTT for length 71000 is:0.0000412671 seconds Communication Time:0.0000206336 seconds

RTT for length 76000 is:0.0000428708 seconds Communication Time:0.0000214354 seconds

RTT for length 81000 is:0.0000458480 seconds Communication Time:0.0000229240 seconds

RTT for length 86000 is:0.0000475934 seconds Communication Time:0.0000237967 seconds

RTT for length 91000 is:0.0000499694 seconds Communication Time:0.0000249847 seconds

RTT for length 96000 is:0.0000510303 seconds Communication Time:0.0000255151 seconds

mc19 112 $ mpirun -np 4 ./test2

No protocol specified

RTT for length 1000 is:0.000010 seconds Communication Time:0.0000052006 seconds

RTT for length 6000 is:0.0000248038 seconds Communication Time:0.0000124019 seconds

RTT for length 11000 is:0.0000331639 seconds Communication Time:0.0000165819 seconds

RTT for length 16000 is:0.0000406292 seconds Communication Time:0.0000203146 seconds

RTT for length 21000 is:0.0000475225 seconds Communication Time:0.0000237613 seconds

RTT for length 26000 is:0.0000564350 seconds Communication Time:0.0000282175 seconds

RTT for length 31000 is:0.0000638758 seconds Communication Time:0.0000319379 seconds

RTT for length 36000 is:0.0000728299 seconds Communication Time:0.0000364150 seconds

RTT for length 41000 is:0.0000807573 seconds Communication Time:0.0000403786 seconds

RTT for length 46000 is:0.0000880026 seconds Communication Time:0.0000440013 seconds

RTT for length 51000 is:0.0000969249 seconds Communication Time:0.0000484624 seconds

RTT for length 56000 is:0.0001055220 seconds Communication Time:0.0000527610 seconds

RTT for length 61000 is:0.0001117944 seconds Communication Time:0.0000558972 seconds

RTT for length 66000 is:0.0001212202 seconds Communication Time:0.0000606101 seconds

RTT for length 71000 is:0.0001271700 seconds Communication Time:0.0000635850 seconds

RTT for length 76000 is:0.0001351437 seconds Communication Time:0.0000675719 seconds

RTT for length 81000 is:0.0001454202 seconds Communication Time:0.0000727101 seconds

RTT for length 86000 is:0.0001532473 seconds Communication Time:0.0000766237 seconds

RTT for length 91000 is:0.0001607640 seconds Communication Time:0.0000803820 seconds

RTT for length 96000 is:0.0001703732 seconds Communication Time:0.0000851866 seconds

mc19 113 $

mc19 113 $

mc19 113 $ mpirun -np 8 ./test2

No protocol specified

RTT for length 1000 is:0.000010 seconds Communication Time:0.0000052256 seconds

RTT for length 6000 is:0.0000294471 seconds Communication Time:0.0000147235 seconds

RTT for length 11000 is:0.0000369246 seconds Communication Time:0.0000184623 seconds

RTT for length 16000 is:0.0000459116 seconds Communication Time:0.0000229558 seconds

RTT for length 21000 is:0.0000547177 seconds Communication Time:0.0000273589 seconds

RTT for length 26000 is:0.0000625033 seconds Communication Time:0.0000312517 seconds

RTT for length 31000 is:0.0000692256 seconds Communication Time:0.0000346128 seconds

RTT for length 36000 is:0.0000782994 seconds Communication Time:0.0000391497 seconds

RTT for length 41000 is:0.0000870945 seconds Communication Time:0.0000435472 seconds

RTT for length 46000 is:0.0000957515 seconds Communication Time:0.0000478757 seconds

RTT for length 51000 is:0.0001030824 seconds Communication Time:0.0000515412 seconds

RTT for length 56000 is:0.0001114424 seconds Communication Time:0.0000557212 seconds

RTT for length 61000 is:0.0001195030 seconds Communication Time:0.0000597515 seconds

RTT for length 66000 is:0.0001289471 seconds Communication Time:0.0000644735 seconds

RTT for length 71000 is:0.0001389315 seconds Communication Time:0.0000694657 seconds

RTT for length 76000 is:0.0001443545 seconds Communication Time:0.0000721772 seconds

RTT for length 81000 is:0.0001536458 seconds Communication Time:0.0000768229 seconds

RTT for length 86000 is:0.0001614313 seconds Communication Time:0.0000807157 seconds

RTT for length 91000 is:0.0001707753 seconds Communication Time:0.0000853876 seconds

RTT for length 96000 is:0.0001793235 seconds Communication Time:0.0000896618 seconds

mc19 190 $ mpirun -np 16 ./test2

No protocol specified

RTT for length 1000 is:0.000009 seconds Communication Time:0.0000046017 seconds

RTT for length 6000 is:0.0000242331 seconds Communication Time:0.0000121165 seconds

RTT for length 11000 is:0.0000305880 seconds Communication Time:0.0000152940 seconds

RTT for length 16000 is:0.0000366472 seconds Communication Time:0.0000183236 seconds

RTT for length 21000 is:0.0000428616 seconds Communication Time:0.0000214308 seconds

RTT for length 26000 is:0.0000497543 seconds Communication Time:0.0000248772 seconds

RTT for length 31000 is:0.0000568836 seconds Communication Time:0.0000284418 seconds

RTT for length 36000 is:0.0000631157 seconds Communication Time:0.0000315578 seconds

RTT for length 41000 is:0.0000701868 seconds Communication Time:0.0000350934 seconds

RTT for length 46000 is:0.0000771297 seconds Communication Time:0.0000385648 seconds

RTT for length 51000 is:0.0000827886 seconds Communication Time:0.0000413943 seconds

RTT for length 56000 is:0.0000936536 seconds Communication Time:0.0000468268 seconds

RTT for length 61000 is:0.0001027604 seconds Communication Time:0.0000513802 seconds

RTT for length 66000 is:0.0001107403 seconds Communication Time:0.0000553701 seconds

RTT for length 71000 is:0.0001160362 seconds Communication Time:0.0000580181 seconds

RTT for length 76000 is:0.0001224290 seconds Communication Time:0.0000612145 seconds

RTT for length 81000 is:0.0001301803 seconds Communication Time:0.0000650902 seconds

RTT for length 86000 is:0.0001357335 seconds Communication Time:0.0000678668 seconds

RTT for length 91000 is:0.0001379012 seconds Communication Time:0.0000689506 seconds

RTT for length 96000 is:0.0001490039 seconds Communication Time:0.0000745019 seconds

mc19 116 $ mpirun -np 32 ./test2

No protocol specified

RTT for length 1000 is:0.000012 seconds Communication Time:0.0000058011 seconds

RTT for length 6000 is:0.0000268810 seconds Communication Time:0.0000134405 seconds

RTT for length 11000 is:0.0000345468 seconds Communication Time:0.0000172734 seconds

RTT for length 16000 is:0.0000432273 seconds Communication Time:0.0000216137 seconds

RTT for length 21000 is:0.0000589778 seconds Communication Time:0.0000294889 seconds

RTT for length 26000 is:0.0000672932 seconds Communication Time:0.0000336466 seconds

RTT for length 31000 is:0.0000776650 seconds Communication Time:0.0000388325 seconds

RTT for length 36000 is:0.0000873481 seconds Communication Time:0.0000436740 seconds

RTT for length 41000 is:0.0000970813 seconds Communication Time:0.0000485406 seconds

RTT for length 46000 is:0.0001054501 seconds Communication Time:0.0000527251 seconds

RTT for length 51000 is:0.0001169610 seconds Communication Time:0.0000584805 seconds

RTT for length 56000 is:0.0001276384 seconds Communication Time:0.0000638192 seconds

RTT for length 61000 is:0.0001365185 seconds Communication Time:0.0000682592 seconds

RTT for length 66000 is:0.0001435533 seconds Communication Time:0.0000717766 seconds

RTT for length 71000 is:0.0001526983 seconds Communication Time:0.0000763491 seconds

RTT for length 76000 is:0.0001654247 seconds Communication Time:0.0000827124 seconds

RTT for length 81000 is:0.0001771104 seconds Communication Time:0.0000885552 seconds

RTT for length 86000 is:0.0001838650 seconds Communication Time:0.0000919325 seconds

RTT for length 91000 is:0.0001873538 seconds Communication Time:0.0000936769 seconds

RTT for length 96000 is:0.0001852595 seconds Communication Time:0.0000926298 seconds

Execute the code:

Code will be found inside hw4/question2/ folder

Compile: mpic++ -o main main.cpp

Execute: mpirun -np 2 ./main

mpirun -np 4 ./main

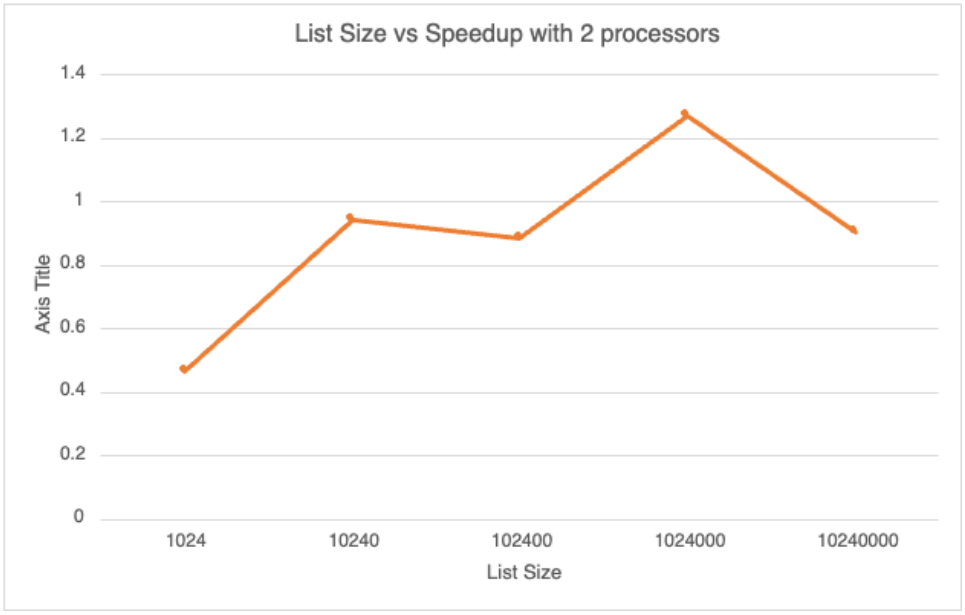
mpirun -np 8 ./main

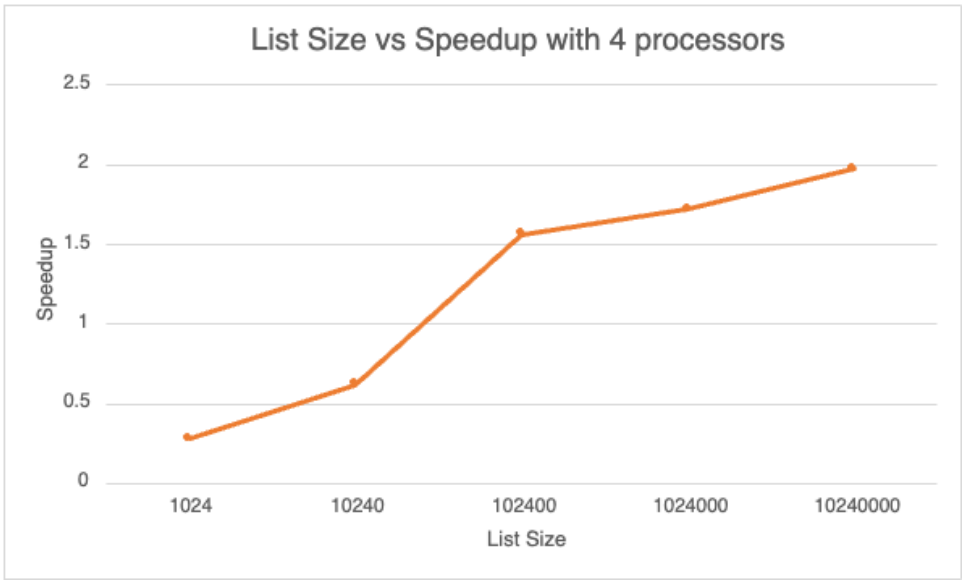
mpirun -np 16 ./main

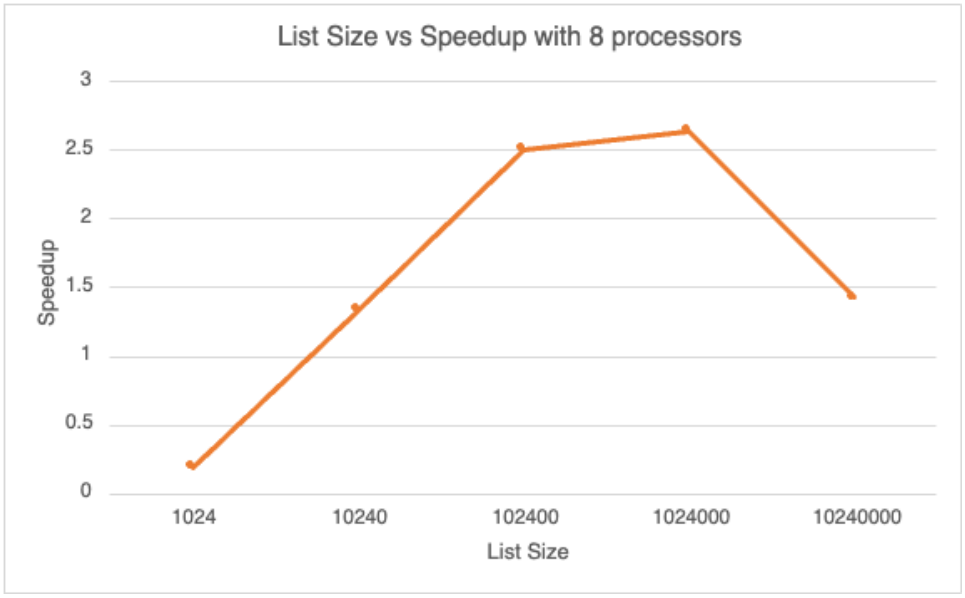
mpirun -np 32 ./main

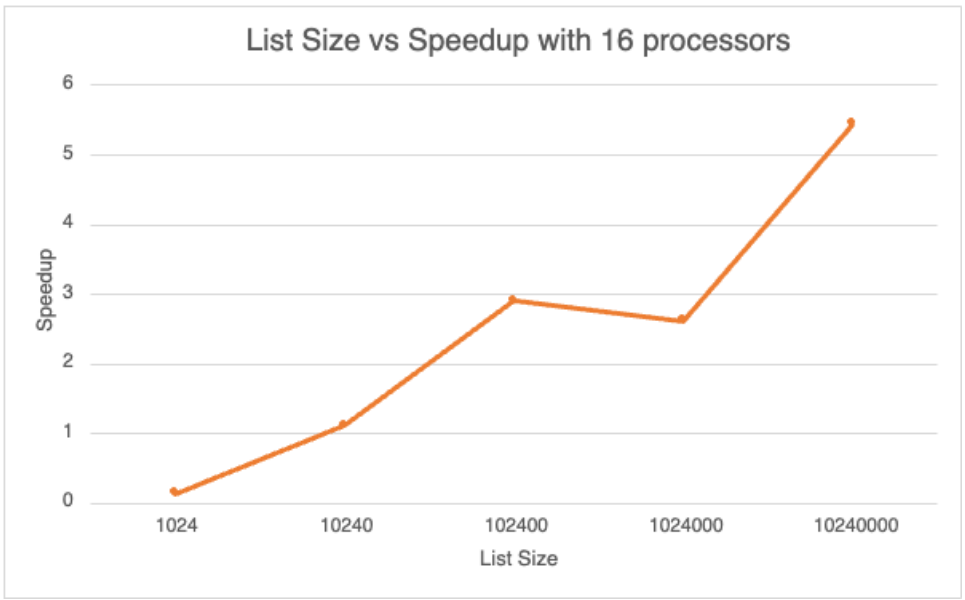
Q3.

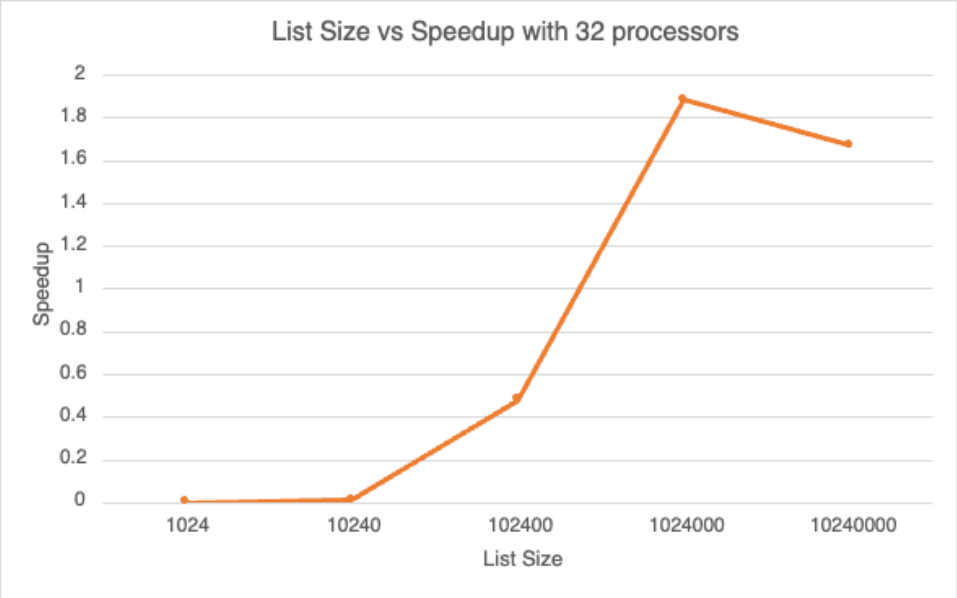
Following plots define the speedup as a function of list size on different no of processors (2,4,8,16,32)






List Size vs Speedup with 8 processors
Speedup
3
2.5
2
1.5
1
0.5
0
1024
10240
102400
1024000
10240000
List Size


List Size vs Speedup with 16 processors
Speedup
6
5
4
3
2
1
0
1024
10240
102400
1024000
10240000
List Size



Output of the code:

mc19 166 $ mpirun -np 2 ./test3

No protocol specified

Length: 1024 parallel time: 0.000456623 serial time: 0.000213645 SpeedUp: 0.467881

Length: 10240 parallel time: 0.00335427 serial time: 0.00316996 SpeedUp: 0.945052

Length: 102400 parallel time: 0.0745924 serial time: 0.0661023 SpeedUp: 0.886181

Length: 1024000 parallel time: 0.628553 serial time: 0.799935 SpeedUp: 1.27266

Length: 10240000 parallel time: 10.9217 serial time: 9.88901 SpeedUp: 0.905449

mc19 167 $

mc19 167 $ mpirun -np 4 ./test3

No protocol specified

Length: 1024 parallel time: 0.000741157 serial time: 0.000207289 SpeedUp: 0.279683

Length: 10240 parallel time: 0.00403676 serial time: 0.00249725 SpeedUp: 0.618627

Length: 102400 parallel time: 0.020087 serial time: 0.0313618 SpeedUp: 1.5613

Length: 1024000 parallel time: 0.225086 serial time: 0.387197 SpeedUp: 1.72021

Length: 10240000 parallel time: 2.89885 serial time: 5.72479 SpeedUp: 1.97485

mc19 168 $

mc19 168 $ mpirun -np 8 ./test3

No protocol specified

Length: 1024 parallel time: 0.00102129 serial time: 0.000198489 SpeedUp: 0.194351

Length: 10240 parallel time: 0.00186463 serial time: 0.00249921 SpeedUp: 1.34033

Length: 102400 parallel time: 0.0126437 serial time: 0.0317304 SpeedUp: 2.50959

Length: 1024000 parallel time: 0.143719 serial time: 0.379208 SpeedUp: 2.63854

Length: 10240000 parallel time: 3.05704 serial time: 4.37954 SpeedUp: 1.43261

mc19 169 $

mc19 169 $ mpirun -np 16 ./test3

No protocol specified

Length: 1024 parallel time: 0.00147156 serial time: 0.000198979 SpeedUp: 0.135216

Length: 10240 parallel time: 0.00224352 serial time: 0.00250165 SpeedUp: 1.11506

Length: 102400 parallel time: 0.0110039 serial time: 0.0319988 SpeedUp: 2.90794

Length: 1024000 parallel time: 0.146465 serial time: 0.383213 SpeedUp: 2.61641

Length: 10240000 parallel time: 0.968869 serial time: 5.27022 SpeedUp: 5.43957

mc19 170 $

mc19 170 $ mpirun -np 32 ./test3

No protocol specified

Length: 1024 parallel time: 0.236775 serial time: 0.0002112 SpeedUp: 0.000891987

Length: 10240 parallel time: 0.223235 serial time: 0.00272214 SpeedUp: 0.0121941

Length: 102400 parallel time: 0.13509 serial time: 0.0647388 SpeedUp: 0.479229

Length: 1024000 parallel time: 0.204927 serial time: 0.386571 SpeedUp: 1.88638

Length: 10240000 parallel time: 2.4948 serial time: 4.16813 SpeedUp: 1.67073

Execute the code:

Code will be found inside hw4/question3/ folder

Compile: mpic++ -o quicksort_mpi_1 quicksort_mpi_1.cpp

Execute: mpirun -np 2 ./quicksort_mpi_1

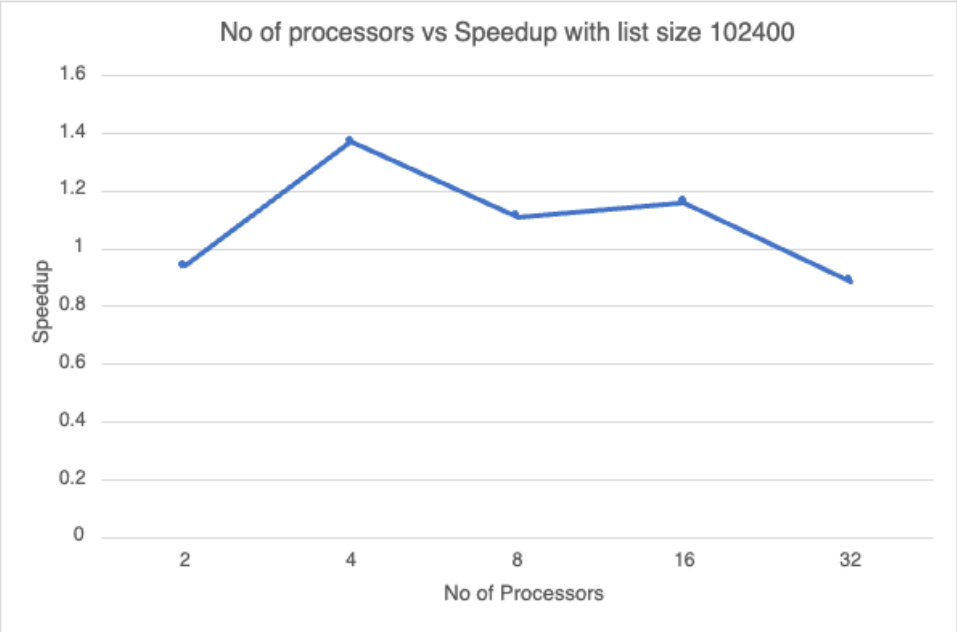
mpirun -np 4 ./quicksort_mpi_1

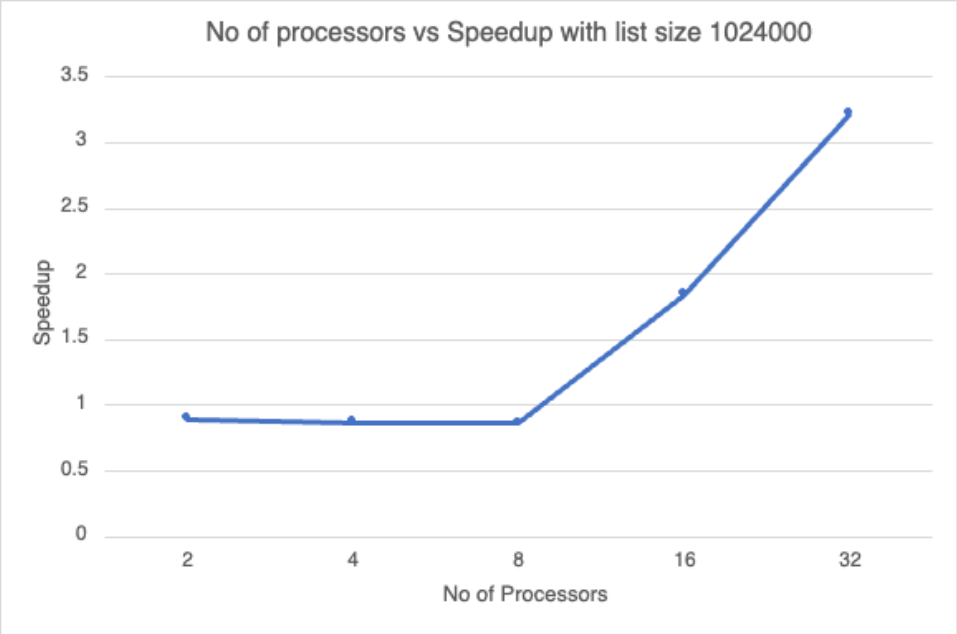
mpirun -np 8 ./quicksort_mpi_1

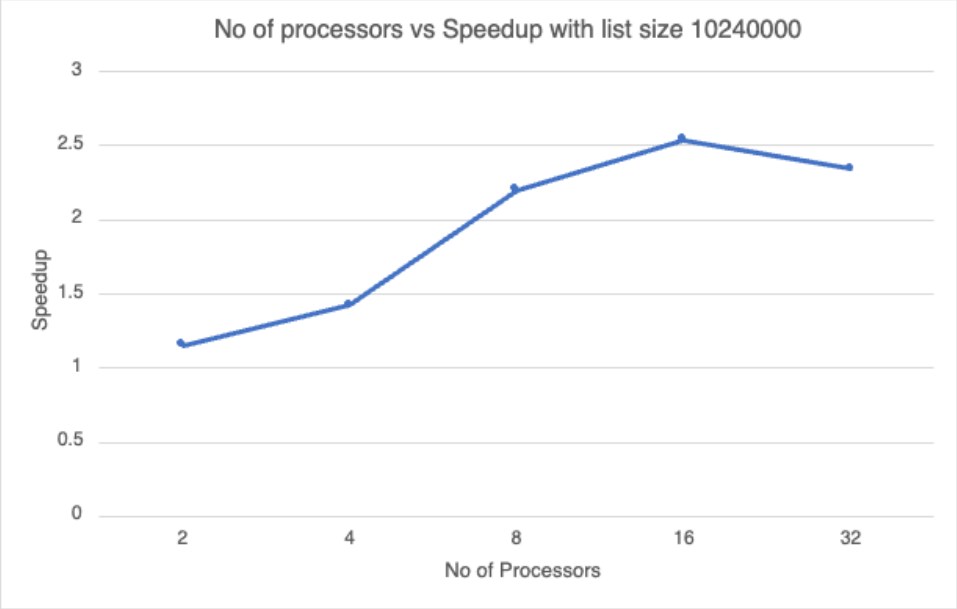
mpirun -np 16 ./quicksort_mpi_1

mpirun -np 32 ./quicksort_mpi_1

Following plots define the speedup as a function of p on different list sizes (100K, 1000K, 10000K)







Output of the code:

mc19 174 $ mpirun -np 2 ./test4 102400

No protocol specified

Length: 102400 parallel time: 0.0762272 serial time: 0.0718086 SpeedUp: 0.942034

mc19 175 $ mpirun -np 4 ./test4 102400

No protocol specified

Length: 102400 parallel time: 0.0224132 serial time: 0.0306984 SpeedUp: 1.36966

mc19 176 $ mpirun -np 8 ./test4 102400

No protocol specified

Length: 102400 parallel time: 0.0258598 serial time: 0.0287541 SpeedUp: 1.11192

mc19 177 $ mpirun -np 16 ./test4 102400

No protocol specified

Length: 102400 parallel time: 0.0258168 serial time: 0.0300051 SpeedUp: 1.16223

mc19 178 $ mpirun -np 32 ./test4 102400

No protocol specified

Length: 102400 parallel time: 0.0327111 serial time: 0.0290366 SpeedUp: 0.887668

mc19 179 $

mc19 179 $ mpirun -np 2 ./test4 1024000

No protocol specified

Length: 1024000 parallel time: 1.0282 serial time: 0.923688 SpeedUp: 0.898352

mc19 180 $ mpirun -np 4 ./test4 1024000

No protocol specified

Length: 1024000 parallel time: 0.387513 serial time: 0.336135 SpeedUp: 0.867417

mc19 181 $ mpirun -np 8 ./test4 1024000

No protocol specified

Length: 1024000 parallel time: 0.391329 serial time: 0.336981 SpeedUp: 0.861119

mc19 182 $ mpirun -np 16 ./test4 1024000

No protocol specified

Length: 1024000 parallel time: 0.183603 serial time: 0.337975 SpeedUp: 1.8408

mc19 183 $ mpirun -np 32 ./test4 1024000

No protocol specified

Length: 1024000 parallel time: 0.106913 serial time: 0.343873 SpeedUp: 3.21639

mc19 184 $

mc19 184 $ mpirun -np 2 ./test4 10240000

No protocol specified

Length: 10240000 parallel time: 8.88062 serial time: 10.2525 SpeedUp: 1.15448

mc19 185 $ mpirun -np 4 ./test4 10240000

No protocol specified

Length: 10240000 parallel time: 2.78851 serial time: 3.96375 SpeedUp: 1.42146

mc19 186 $ mpirun -np 8 ./test4 10240000

No protocol specified

Length: 10240000 parallel time: 1.81443 serial time: 3.99653 SpeedUp: 2.20264

mc19 187 $ mpirun -np 16 ./test4 10240000

No protocol specified

Length: 10240000 parallel time: 1.6449 serial time: 4.17748 SpeedUp: 2.53966

mc19 188 $ mpirun -np 32 ./test4 10240000

No protocol specified

Length: 10240000 parallel time: 1.71174 serial time: 4.00724 SpeedUp: 2.34103

Execute the code:

Code will be found inside hw4/question3/ folder

Compile: mpic++ -o quicksort_mpi_2 quicksort_mpi_2.cpp

Execute: mpirun -np 2 ./quicksort_mpi_2 102400

mpirun -np 4 ./quicksort_mpi_2 102400

mpirun -np 8 ./quicksort_mpi_2 102400

mpirun -np 16 ./quicksort_mpi_2 102400

mpirun -np 32 ./quicksort_mpi_2 102400

Here, I am passing the list size (102400, 1024000, 10240000) as command line argument while calculating the speedup as a function of p.