

CSCI 6905 High Performance Computing

Assignment 02

Anil Adhikari

adhikaria16@students.ecu.edu

Part 1:

- The primary purpose of this part is to evaluate the performance of a program while calculating sum of array elements in two different scenarios. First scenario is calculating sum of an array with given number of elements on serial computation. And second scenario is calculating sum of the same array with same number of elements on parallel computation.
- This part is solved using Java 8 with `RecursiveTask<T>`.
- The overridden method `compute()` in the private class which extends `RecursiveTask` is called recursively while doing parallel computation. Inside this method, a condition is checked (base case length of the array or subarray) which determines whether to continue forking or perform serial computation. This is the point which determines further parallelism is needed or not.
- Prohibiting the creation of threads for small size array increases the performance. For small size array, creation of threads is overhead and results in more time consuming. So, this program is designed to perform serial computation when the size of array or subarray becomes less than or equal to the *base case length*.
- This program uses 1000000 as *base case length* of the array or subarray which determines whether to perform parallel computation or serial computation and is used in `compute()` method.
- While creating `ForkJoinPool` for threads, this program asks the user to enter number of threads that the user wants to create. If 0 value is entered, this program will create the number of threads depending on the availability of processors.
- This program is made interactive so that the user can see the change in performance of the program while changing options like number of threads and size of array.
- Elements of the array are generated using random number generator of Java. In this case numbers between 1 and 100 are generated.
- And, size of the array is limited to 100000000 because if `Integer.MAX_VALUE` is used for the size, it will result in error with this message "Exception in thread "main" java.lang.OutOfMemoryError: Java heap space". This is because of the limited memory space provided for JVM.
- The test cases below try to illustrate the performance in three different cases of base case length (10000, 1000000 and 100000000).

When the base case length is 1000000:

Test Case 1:

Enter number of threads (0 for default): 0
Enter size for array (maximum 1000000000): 10000

Base case length of array or subarray: 1000000

Starting Parallel Summation...

Total time taken: 12.94355

Final sum: 509421

=====

Starting Serial Summation...

Total time taken: 0.121413

Final sum: 509421

Test Case 2:

Enter number of threads (0 for default): 0
Enter size for array (maximum 1000000000): 100000000

Base case length of array or subarray: 1000000

Starting Parallel Summation...

Total time taken: 405.164165

Final sum: 5049690257

=====

Starting Serial Summation...

Total time taken: 705.014934

Final sum: 5049690257

Test Case 3:

Enter number of threads (0 for default): 2
Enter size for array (maximum 1000000000): 10000

Base case length of array or subarray: 1000000

Starting Parallel Summation...

Total time taken: 9.366849

Final sum: 500363

=====

Starting Serial Summation...

Total time taken: 0.136438

Final sum: 500363

Test Case 4:

Enter number of threads (0 for default): 2
Enter size for array (maximum 100000000): 100000000

Base case length of array or subarray: 1000000

Starting Parallel Summation...
Total time taken: 438.983658
Final sum: 5049889982

=====
Starting Serial Summation...
Total time taken: 695.081569
Final sum: 5049889982

Test Case 5:

Enter number of threads (0 for default): 8
Enter size for array (maximum 100000000): 10000

Base case length of array or subarray: 1000000

Starting Parallel Summation...
Total time taken: 4.893467
Final sum: 509275

=====
Starting Serial Summation...
Total time taken: 0.309622
Final sum: 509275

Test Case 6:

Enter number of threads (0 for default): 8
Enter size for array (maximum 100000000): 100000000

Base case length of array or subarray: 1000000

Starting Parallel Summation...
Total time taken: 493.964814
Final sum: 5049910540

=====
Starting Serial Summation...
Total time taken: 702.460307
Final sum: 5049910540

When base case length is 10000

Test Case 1:

Enter number of threads (0 for default): 0
Enter size for array (maximum 1000000000): 10000

Base case length of array or subarray: 10000

Starting Parallel Summation...
Total time taken: 9.202438
Final sum: 503652

=====

Starting Serial Summation...
Total time taken: 0.085598
Final sum: 503652

Test Case 2:

Enter number of threads (0 for default): 0
Enter size for array (maximum 1000000000): 1000000000

Base case length of array or subarray: 10000

Starting Parallel Summation...
Total time taken: 528.823041
Final sum: 4999756219

=====

Starting Serial Summation...
Total time taken: 698.144087
Final sum: 4999756219

Test Case 3:

Enter number of threads (0 for default): 2
Enter size for array (maximum 1000000000): 10000

Base case length of array or subarray: 10000

Starting Parallel Summation...
Total time taken: 7.451822
Final sum: 501219

=====

Starting Serial Summation...
Total time taken: 0.159911
Final sum: 501219

Test Case 4:

Enter number of threads (0 for default): 2
Enter size for array (maximum 1000000000): 100000000

Base case length of array or subarray: 10000

Starting Parallel Summation...
Total time taken: 508.647243
Final sum: 5000060992

=====
Starting Serial Summation...
Total time taken: 909.933193
Final sum: 5000060992

Test Case 5:

Enter number of threads (0 for default): 8
Enter size for array (maximum 1000000000): 10000

Base case length of array or subarray: 10000

Starting Parallel Summation...
Total time taken: 12.835572
Final sum: 498926

=====
Starting Serial Summation...
Total time taken: 0.30942
Final sum: 498926

Test Case 6:

Enter number of threads (0 for default): 8
Enter size for array (maximum 1000000000): 100000000

Base case length of array or subarray: 10000

Starting Parallel Summation...
Total time taken: 642.78492
Final sum: 4999759539

=====
Starting Serial Summation...
Total time taken: 702.594369
Final sum: 4999759539

When base case length is 100000000

Test Case 1:

Enter number of threads (0 for default): 0
Enter size for array (maximum 1000000000): 10000
Base case length of array or subarray: 100000000

Starting Parallel Summation...
Total time taken: 8.860883
Final sum: 493371

=====
Starting Serial Summation...
Total time taken: 0.287485
Final sum: 493371

Test Case 2:

Enter number of threads (0 for default): 0
Enter size for array (maximum 1000000000): 100000000
Base case length of array or subarray: 100000000

Starting Parallel Summation...
Total time taken: 753.02634
Final sum: 4999908255

=====
Starting Serial Summation...
Total time taken: 697.801018
Final sum: 4999908255

Test Case 3:

Enter number of threads (0 for default): 2
Enter size for array (maximum 1000000000): 10000
Base case length of array or subarray: 100000000

Starting Parallel Summation...
Total time taken: 6.094541
Final sum: 499860

=====
Starting Serial Summation...
Total time taken: 0.332845
Final sum: 499860

Test Case 4:

Enter number of threads (0 for default): 2
Enter size for array (maximum 1000000000): 1000000000

Base case length of array or subarray: 1000000000

Starting Parallel Summation...
Total time taken: 753.183033
Final sum: 5000325367

=====
Starting Serial Summation...
Total time taken: 698.156368
Final sum: 5000325367

Test Case 5:

Enter number of threads (0 for default): 8
Enter size for array (maximum 1000000000): 10000

Base case length of array or subarray: 1000000000

Starting Parallel Summation...
Total time taken: 8.439026
Final sum: 501136

=====
Starting Serial Summation...
Total time taken: 0.326306
Final sum: 501136

Test Case 6:

Enter number of threads (0 for default): 8
Enter size for array (maximum 1000000000): 1000000000

Base case length of array or subarray: 1000000000

Starting Parallel Summation...
Total time taken: 752.136681
Final sum: 4999723698

=====
Starting Serial Summation...
Total time taken: 694.539181
Final sum: 4999723698

Part 2:

- This part of the assignment implements the RadixSort algorithm.
- The solution use RecursiveTask<T> in Java 8.
- Input for the program is given from file: Input.txt
- This program writes in two output file:
 - outputforparallel.txt for parallel computation
 - outputforserial.txt for serial computation
- This program checks whether these files are readable and writable depending on the case at first and prints the messages.
- The primary purpose of this program is to provide information related to the performance along with the correct result after sorting.
- This program is focused on sorting strings using MSD.
- In the parallel computation, thread keeps forking until the bucket for a particular alphabet is empty. So, due to the overhead of fork and join, parallel computation is slower than serial one.
- This program use default number of threads based on the availability of processor during runtime.

Test Case 1:

Input file: Input.txt

The input file contains: bac cba bca acb abc cab

Output file:

outputforparallel.txt

This file contains: Input: [bac, cba, bca, acb, abc, cab]

Output: [abc, acb, bac, bca, cab, cba]

outputforserial.txt

This file contains: Input: [bac, cba, bca, acb, abc, cab]

Output: [abc, acb, bac, bca, cab, cba]

Console:

Input file name is: src/assignment2/Input.txt

Output file name for writing words is: src/assignment2/outputforparallel.txt

Output file name for writing words is: src/assignment2/outputforserial.txt

src/assignment2/outputforparallel.txt successfully opened for writing

src/assignment2/outputforserial.txt successfully opened for writing

Starting Parallel Radix Sort...

Total time taken: 4.827547

Sorted array: [abc, acb, bac, bca, cab, cba]

=====

Starting Serial Radix Sort...

Total time taken: 0.352493
Sorted array: [abc, acb, bac, bca, cab, cba]

Test Case 2:

Input file: Input.txt

The input file contains: Soc. I believe that I know Phaedrus about as well as I know myself, and I am very sure that the speech of Lysias was repeated to him, not once only, but again and again;-he insisted on hearing it many times over and Lysias was very willing to gratify him; at last, when nothing else would do, he got hold of the book, and looked at what he most wanted to see,-this occupied him during the whole morning; -and then when he was tired with sitting, he went out to take a walk, not until, by the dog, as I believe, he had simply learned by heart the entire discourse, unless it was unusually long, and he went to a place outside the wall that he might practise his lesson. There he saw a certain lover of discourse who had a similar weakness;-he saw and rejoiced; now thought he, "I shall have a partner in my revels." And he invited him to come and walk with him. But when the lover of discourse begged that he would repeat the tale, he gave himself airs and said, "No I cannot," as if he were indisposed; although, if the hearer had refused, he would sooner or later have been compelled by him to listen whether he would or no. Therefore, Phaedrus, bid him do at once what he will soon do whether bidden or not.

Output file:

outputforparallel.txt

This file contains:

Input: [soc, i, believe, that, i, know, phaedrus, about, as, well, as, i, know, myself, and, i, am, very, sure, that, the, speech, of, lysias, was, repeated, to, him, not, once, only, but, again, and, againhe, insisted, on, hearing, it, many, times, over, and, lysias, was, very, willing, to, gratify, him, at, last, when, nothing, else, would, do, he, got, hold, of, the, book, and, looked, at, what, he, most, wanted, to, seethis, occupied, him, during, the, whole, morning, and, then, when, he, was, tired, with, sitting, he, went, out, to, take, a, walk, not, until, by, the, dog, as, i, believe, he, had, simply, learned, by, heart, the, entire, discourse, unless, it, was, unusually, long, and, he, went, to, a, place, outside, the, wall, that, he, might, practise, his, lesson, there, he, saw, a, certain, lover, of, discourse, who, had, a, similar, weaknesshe, saw, and, rejoiced, now, thought, he, i, shall, have, a, partner, in, my, revels, and, he, invited, him, to, come, and, walk, with, him, but, when, the, lover, of, discourse, begged, that, he, would, repeat, the, tale, he, gave, himself, airs, and, said, no, i, cannot, as, if, he, were, indisposed, although, if, the, hearer, had, refused, he, would, sooner, or, later, have, been, compelled, by, him, to, listen, whether, he, would, or, no, therefore, phaedrus, bid, him, do, at, once, what, he, will, soon, do, whether, bidden, or, not]

Output: [about, againhe, againhe, airs, although, am, and, and, and, and, and, and, and, and, as, as, as, as, at, at, at, at, airs, and, as, although, at, been, begged, believe, believe, bidden, bidden, book, but, but, by, by, by, cannot, certain, come, compelled, discourse, discourse, discourse, dog, dog, do,

do, during, else, entire, gave, got, gratify, had, had, had, have, have, hearer, hearing, heart, he, he, he, heart, he, he, he, he, he, he, he, hearer, he, he, he, himself, him, him, him, him, himself, him, him, his, hold, if, if, indisposed, insisted, invited, indisposed, it, it, i, in, invited, i, if, indisposed, if, know, know, last, later, learned, lesson, listen, long, looked, lover, lover, lysias, lysias, many, might, morning, most, myself, my, nothing, nothing, not, not, now, no, not, occupied, of, of, of, of, once, once, only, once, or, or, or, outside, outside, over, partner, phaedrus, phaedrus, place, practise, refused, rejoiced, repeated, repeat, revels, said, saw, saw, seethis, shall, similar, simply, sitting, soc, sooner, soon, speech, sure, take, tale, that, that, that, that, then, therefore, therefore, then, the, the, the, there, the, the, the, therefore, thought, times, tired, to, to, to, to, to, to, to, to, unless, until, unusually, very, very, walk, walk, wall, wanted, was, was, was, was, weaknesshe, well, went, went, were, what, what, when, when, when, whether, whether, whole, who, willing, will, with, with, would, would, would, would]

outputforserial.txt:

This file contains:

Input: [soc, i, believe, that, i, know, phaedrus, about, as, well, as, i, know, myself, and, i, am, very, sure, that, the, speech, of, lysias, was, repeated, to, him, not, once, only, but, again, and, againhe, insisted, on, hearing, it, many, times, over, and, lysias, was, very, willing, to, gratify, him, at, last, when, nothing, else, would, do, he, got, hold, of, the, book, and, looked, at, what, he, most, wanted, to, seethis, occupied, him, during, the, whole, morning, and, then, when, he, was, tired, with, sitting, he, went, out, to, take, a, walk, not, until, by, the, dog, as, i, believe, he, had, simply, learned, by, heart, the, entire, discourse, unless, it, was, unusually, long, and, he, went, to, a, place, outside, the, wall, that, he, might, practise, his, lesson, there, he, saw, a, certain, lover, of, discourse, who, had, a, similar, weaknesshe, saw, and, rejoiced, now, thought, he, i, shall, have, a, partner, in, my, revels, and, he, invited, him, to, come, and, walk, with, him, but, when, the, lover, of, discourse, begged, that, he, would, repeat, the, tale, he, gave, himself, airs, and, said, no, i, cannot, as, if, he, were, indisposed, although, if, the, hearer, had, refused, he, would, sooner, or, later, have, been, compelled, by, him, to, listen, whether, he, would, or, no, therefore, phaedrus, bid, him, do, at, once, what, he, will, soon, do, whether, bidden, or, not]

Output: [about, againhe, againhe, airs, although, am, and, and, and, and, and, and, and, and, and, and, as, as, as, as, at, at, at, airs, and, as, although, at, been, begged, believe, believe, bidden, bidden, book, but, but, by, by, by, cannot, certain, come, compelled, discourse, discourse, discourse, dog, dog, do, do, during, else, entire, gave, got, gratify, had, had, had, have, have, hearer, hearing, heart, he, he, he, heart, he, he, he, he, he, he, he, hearer, he, he, he, himself, him, him, him, him, himself, him, him, his, hold, if, if, indisposed, insisted, invited, indisposed, it, it, i, in, invited, i, if, indisposed, if, know, know, last, later, learned, lesson, listen, long, looked, lover, lover, lysias, lysias, many, might, morning, most, myself, my, nothing, nothing, not, not, now, no, not, occupied, of, of, of, of, once, once, only, once, or, or, or, outside, outside, over, partner, phaedrus, phaedrus, place, practise, refused, rejoiced, repeated, repeat, revels, said, saw, saw, seethis, shall, similar, simply, sitting, soc, sooner, soon, speech, sure, take, tale, that, that, that, that, then, therefore, therefore, then, the, the, the, there, the, the, the, therefore, thought, times, tired, to, to, to, to, to, to, to, to, unless, until, unusually, very, very, walk, walk, wall, wanted, was, was, was, was, weaknesshe, well, went, went, were, what, what, when, when, when, whether, whether, whole, who, willing, will, with, with, would, would, would, would]

Console:

Input file name is: src/assignment2/Input.txt

Output file name for writing words is: src/assignment2/outputforparallel.txt

Output file name for writing words is: src/assignment2/outputforserial.txt

src/assignment2/outputforparallel.txt successfully opened for writing

src/assignment2/outputforserial.txt successfully opened for writing

Starting Parallel Radix Sort...

Total time taken: 24.5621

Sorted array: [about, againhe, againhe, airs, although, am, and, and, and, and, and, and, and, and, as, as, as, as, at, at, at, airs, and, as, although, at, been, begged, believe, believe, bidden, bidden, book, but, but, by, by, by, cannot, certain, come, compelled, discourse, discourse, discourse, dog, dog, do, do, during, else, entire, gave, got, gratify, had, had, had, have, have, hearer, hearing, heart, he, he, he, heart, he, he, he, he, he, he, he, he, hearer, he, he, he, himself, him, him, him, him, himself, him, him, his, hold, if, if, indisposed, insisted, invited, indisposed, it, it, i, in, invited, i, if, indisposed, if, know, know, last, later, learned, lesson, listen, long, looked, lover, lover, lysias, lysias, many, might, morning, most, myself, my, nothing, nothing, not, not, now, no, not, occupied, of, of, of, of, once, once, only, once, or, or, or, outside, outside, over, partner, phaedrus, phaedrus, place, practise, refused, rejoiced, repeated, repeat, revels, said, saw, saw, seethis, shall, similar, simply, sitting, soc, sooner, soon, speech, sure, take, tale, that, that, that, that, then, therefore, therefore, then, the, the, the, there, the, the, the, therefore, thought, times, tired, to, to, to, to, to, to, to, unless, until, unusually, very, very, walk, walk, wall, wanted, was, was, was, was, weaknesshe, well, went, went, were, what, what, when, when, when, whether, whether, whole, who, willing, will, with, with, would, would, would, would]

=====

Starting Serial Radix Sort...

Total time taken: 5.036526

Sorted array: [about, againhe, againhe, airs, although, am, and, and, and, and, and, and, and, and, as, as, as, as, at, at, at, airs, and, as, although, at, been, begged, believe, believe, bidden, bidden, book, but, but, by, by, by, cannot, certain, come, compelled, discourse, discourse, discourse, dog, dog, do, do, during, else, entire, gave, got, gratify, had, had, had, have, have, hearer, hearing, heart, he, he, he, heart, he, he, he, he, he, he, he, he, hearer, he, he, he, himself, him, him, him, him, himself, him, him, his, hold, if, if, indisposed, insisted, invited, indisposed, it, it, i, in, invited, i, if, indisposed, if, know, know, last, later, learned, lesson, listen, long, looked, lover, lover, lysias, lysias, many, might, morning, most, myself, my, nothing, nothing, not, not, now, no, not, occupied, of, of, of, of, once, once, only, once, or, or, or, outside, outside, over, partner, phaedrus, phaedrus, place, practise, refused, rejoiced, repeated, repeat, revels, said, saw, saw, seethis, shall, similar, simply, sitting, soc, sooner, soon, speech, sure, take, tale, that, that, that, that, then, therefore, therefore, then, the, the, the, there, the, the, the, therefore, thought, times, tired, to, to, to, to, to, to, to, unless, until, unusually, very, very, walk, walk, wall, wanted, was, was, was, was, weaknesshe, well, went, went, were, what, what, when, when, when, whether, whether, whole, who, willing, will, with, with, would, would, would, would]

