Seoul National University

Data Structure

Spring 2025, Kang

Programming Assignment 3: Internal Sorting (Chapter 7)

Due: May 27th, 23:59, submit at eTL

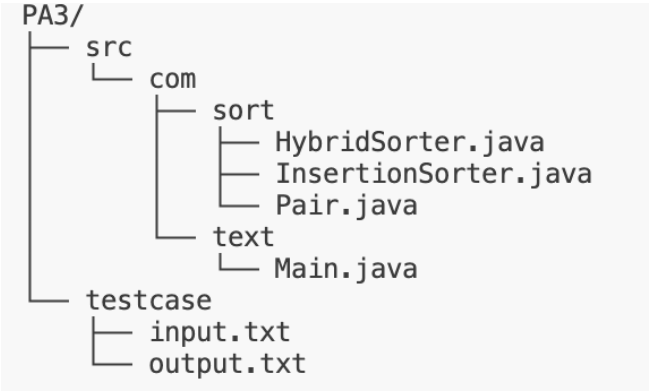
Reminders

- The points of this homework add up to 100.
- Like all homework, this has to be done individually.
- Lead T.A.: Seungho Kim (snuds.ta@gmail.com)
- Write a program in Java **(JDK 21)**.
- Do not use Java Collection Framework and the third-party implementation from the Internet.

1. How to submit the programming assignment

1) Fill in the skeleton code with your own answer.

2) Compress your code as ‘PA3.zip’ file. The structure of your ‘PA3.zip’ file should look like follows:



3) Your code will be compiled and executed with following commands in Linux environment. Make sure that your code runs well with following commands.

```
javac src/com/sort/*.java src/com/text/*.java
java -cp src com.text.Main testcase/input.txt testcase/output.txt
```

4) Submit the PA3.zip file to the eTL (http://etl.snu.ac.kr/).

2. How to grade your programming assignment

1) We made a grading machine for the 'program execution' part. The machine will run your program and compare answers and outputs that your program generates for given inputs. If your program cannot generate correct answers for an input file, it will not give you the point corresponding to the input. Our machine will consider the following scenarios:
   - (***Accept***) When your program generates exact outputs for an input file, the machine will give you the point of the input.
   - (***Wrong Answer***) When your program runs normally, but generates incorrect outputs for an input file, including typos, the machine will not give you the point of the input.
   - (***Run Error***) When your program does not run, or is terminated suddenly for some reasons, the machine will not give you the point of an input file because it cannot generate any outputs.
   - (***Time Limit***) When your program runs over a predefined execution time for an input file, our machine will stop your program, and it will not give you the point of the input. The time limit of the execution is ***5 seconds***.
2) We will generate 10 input files, and assign 5 points for each input file. For example, if your program gets 9 accepts, and 1 wrong answer by the machine, the points for 'program execution' part will be 45 points. Hence, before submitting your programming assignment, please be sure that your program makes correct answers in reasonable time for any input case.

3. Problem

How can we make the quicksort algorithm to have better performance? One of the possible solutions is a hybrid sorting algorithm which combines the quicksort with insertion sorting algorithm. The hybrid sorting algorithm begins with the quicksort and switches to the insertion sorting algorithm when the size of subarray is equal to 32 (The size of the last subarray can be less than 32). This algorithm takes the advantages of both algorithms for achieving practical performance on typical datasets.

Our goal is to implement a program that sorts the given key-value pairs in either lexicographic order for the keys or numerically ascending order for the values using the hybrid sorting algorithm. Fill your code in 'HybridSorter.java' and 'InsertionSorter.java'. Several rules that you **must** follow are as follows:

- Make your program run through Main class. The main class should handle inputs and outputs using standard I/O in JAVA. (input from a keyboard, output to a monitor)
- The number of given key-value pair doesn't exceed 1,000,000.
- All keys and values are distinct.
- All values should be an integer type.
- Your program should be finished within 5 seconds on the PC used for lab session for any test case.
- You should implement all functions listed in Section 4.

4. Interface of Algorithms

1) HybridSorter

Function
void sort(Pair<K, ?>[] array, int left, int right, String sortType, boolean reverse)
Description
- Sorts the elements in given array from left to right in either lexicographic order or numerically ascending order using the hybrid sorting algorithm. - * You might need to create the helper methods in order to proceed the sorting algorithm.

Function
Pair<K,?> search(Pair<K, ?>[] array, int k, string sortType)
Description
- Find the pair which has **k**-th smallest element in the sorted array. - (k) is a parameter as integer.

2) InsertionSorter

Function
void sort(Pair<K, ? >[] array, int left, int right, String sortType, boolean reverse)
Description
- Sorts the elements in given array from left to right in lexicographic or numerically ascending order using the insertion sort algorithm. - * You might need to create the helper methods in order to proceed the sorting algorithm.

5. Specification of I/O

The program should accept only the inputs listed below and print the listed outputs.

1) n

Input form	Output form
`n (#elements)`	
Description	
- Creates the first array of size (#elements). - 'n' command appears at the first line of input. - 'n' command doesn't appear multiple times.	
Example Input	**Example Output**
`n 3`	

2) append

Input form	Output form
`append (key) (value)`	
Description	
- Appends a new pair of which key and values are (key), and (value), respectively. - (key) is a string which doesn't contain any whitespace. - (value) is a string.	
Example Input	**Example Output**
`append data 2`	

3) sort

Input form	Output form
`sort [sortType]`	
Description	
- Sorts the pairs in the array in lexicographic or numerically ascending order using the hybrid sorting algorithm. - sortType should contain either "keys" or "values".	
Example Input	**Example Output**
`sort keys`	

4) sortrev

Input form	Output form
`sortrev [sortType]`	
Description	

- Sorts the pairs in the array in lexicographic or numerically descending order using the hybrid sorting algorithm.
- sortType should contain either “keys” or “values”.

Example Input	Example Output
`sortrev keys`	

5) median

Input form	Output form
`median`	`Median: (key)(value)`
Description	

- Prints the median key-value pair to the console.
- When the merged array is even, key and value are concatenated with a minus sign in between.

Example Input	Example Output
`median` `median`	`Median: cloud 2` `Median: cloud-durian 2-4`

6) print

Input form	Output form
`print`	`Sort by [sortType]: [key : value]`
Description	

- Prints the entire sorted list with keys and values.

Example Input	Example Output
`print`	`Sort by keys: [data : 4] [hello : 5] [structure : 1]`

6. Sample Input

```
n 3

append hello 5

append data 4

append structure 1

sort keys

print

median

sort values

print

median

sortrev values

print

median
```

7. Sample Output

```
Sort by keys: [data : 4] [hello : 5] [structure : 1]

Median: hello 5

Sort by values: [structure : 1] [data : 4] [hello : 5]

Median: data 4

Sort by sortrev values: [hello : 5] [data : 4] [structure : 1]

Median: data 4
```