GTÜ Department of Computer Engineering

CSE 222/505 - Spring 2021

Homework 4 Report

FATİH DOĞAÇ

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1.System Requirements

User must have Java Runtime Environment to run the program.

It can be found here.

Functional Requirements:

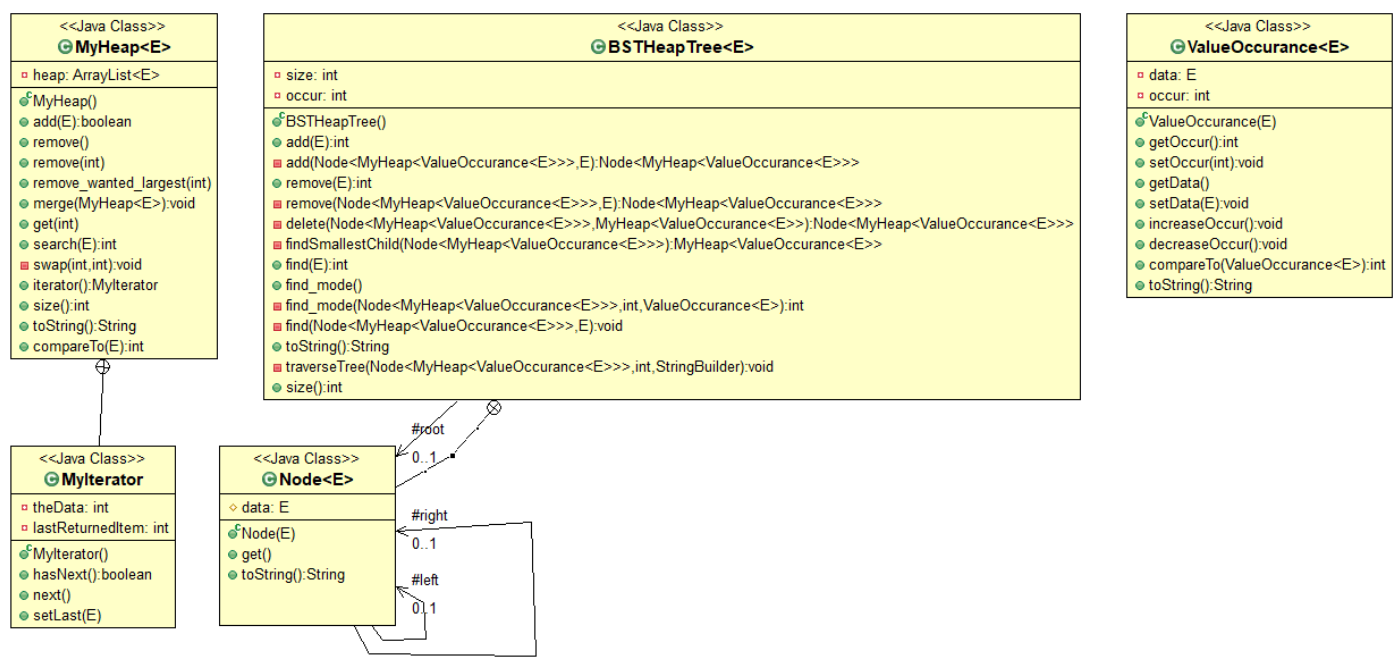User can build a Max-Heap with following features:

- Can add any comparable type of value to the heap.
- Can remove a value from the heap.
- Can remove the i'th largest wanted element from the heap.
- Can merge with another heap.
- Can search the heap for a specific item.
- Can set a data that returned from the iterator.
- Can print the heap.
- Can know the number of elements in the heap.

User can build a BSTHeapTree with following features:

- Can add any comparable type of value to the tree.
- Can remove a value from the tree.
- Can search for a value in the tree.
- Can find the mode of the tree.
- Can print the tree.
- Can know the number of elements in the tree.

There is a driver program for user in the file to see features clearly.

2.Class Diagram:

3.Problem Solution Approach

I had several problems during the creating the project progress.

1. After deleting an element, if the heap that element removed from will become empty , That heap (in other words that binary tree node) needs to deleted. And my method was giving segmentation fault.
2. Keeping the occurrences of the values.

For the first problem, I needed to go deep in the structure and implemented myself a simple binary search tree to understand the node delete method.

Then I fully understood the algorithm then implemented for BSTHeapTree.

For the second problem , after a few hours of thinking and trying to make up something, I came up with an idea of creating an another class which is ValueOccurance. ValueOccurance holds a data and its occurrence. That solved my problem I created the heaps with ValueOccurances in them.

4.TEST CASES

1. Insert the 3000 numbers that are randomly generated in the range 0-5000 into the BSTHeapTree. Store these numbers in an array as well. Sort the numbers to find the number occurrences of all the numbers.
2. Search for 100 numbers in the array and 10 numbers not in the array and make sure that the number of occurrences is correct.
3. Find the mode of the BSTHeapTree. Check whether the mode value is correct.
4. Remove 100 numbers in the array and 10 numbers not in the array and make sure that the number of occurrences after removal is correct.

5. RUNNING AND RESULTS

```
Heap:
[12934, 7323, 423, 1523, 173, 153, 23, 189, 1522, 14, 10]

Removing the root.
Heap:
[7323, 1523, 423, 1522, 173, 153, 23, 189, 10, 14]

Removing the root.
Heap:
[1523, 1522, 423, 189, 173, 153, 23, 14, 10]

Removing fifth largest element.
fifth largest element: 173
Heap:
[1523, 189, 1522, 153, 23, 10, 423, 14]

Removing fourth largest element.
fourth largest element: 189
Heap:
[1523, 153, 1522, 10, 23, 14, 423]

Heap:
[1523, 153, 1522, 10, 23, 14, 423]
Another Heap:
[10000, 4, 2, 1, 3]
Merging heaps:
Heap:
[10000, 1523, 1522, 153, 23, 14, 423, 10, 4, 2, 1, 3]

Searching...(-1 means item is not in the heap.)
Item: 10000 , Index: 0
Item: 23 , Index: 4
Item: 153 , Index: 3
Item: 423 , Index: 6
Item: 14 , Index: 5
Item: 99999 , Index: -1
Item: 123456 , Index: -1
Item: 11 , Index: -1

Printing the heap with an iterator:
10000 1523 1522 153 23 14 423 10 4 2 1 3

Setting the last returned item by the iterator 99999
10000 1523 1522 153 99999 23 14 423 10 4 2 1 3
```

BSTHeapTree:
4983.1 , 4691.1 , 3624.1 , 2412.2 , 3164.1 , 151.2 , 676.2 ,
 2765.2 , 1243.2 , 1271.2 , 126.2 , 938.2 , 879.1 , 1175.1 ,
  1918.2 , 1594.1 , 1886.3 , 52.2 , 917.2 , 1451.1 , 757.2 ,
   1672.1 , 1239.1 , 1537.1 , 986.2 , 1046.1 , 1333.1 , 1181.1 ,
    1609.1 , 983.1 , 1327.1 , 504.1 , 742.3 , 119.1 , 75.1 ,
     1603.1 , 1326.2 , 1287.2 , 590.2 , 820.2 , 64.2 , 433.2 ,
      1524.2 , 962.3 , 1065.1 , 11.1 , 242.3 , 61.1 , 240.2 ,
       1140.1 , 841.1 , 972.2 , 587.1 , 325.3 , 24.5 , 484.2 ,
        999.3 , 861.1 , 877.1 , 351.1 , 552.4 , 27.1 , 304.1 ,
         948.1 , 543.3 , 665.2 , 31.2 , 229.1 , 333.1 , 437.2 ,
          837.1 , 625.1 , 424.1 , 122.1 , 431.3 , 87.1 , 422.1 ,
           756.3 , 630.1 , 672.1 , 91.1 , 268.1 , 417.1 , 471.1 ,
            751.1 , 385.2 , 470.2 , 324.2 , 282.1 , 154.1 , 389.1 ,
             563.1 , 467.2 , 327.2 , 10.2 , 453.1 , 85.2 , 216.2 ,
              556.3 , 316.2 , 450.1 , 134.1 , 231.1 , 178.2 , 114.3 ,
               516.1 , 310.1 , 361.1 , 83.2 , 278.1 , 165.1 , 291.1 ,
                497.1 , 204.2 , 309.2 , 29.1 , 131.1 , 69.3 , 186.3 ,
                 370.2 , 211.2 , 322.2 , 70.1 , 164.3 , 182.1 , 306.2 ,
                  334.1 , 330.1 , 259.2 , 238.2 , 54.2 , 63.2 , 100.2 ,
                   311.3 , 192.2 , 215.3 , 36.2 , 118.2 , 86.2 , 143.1 ,
                    233.2 , 138.3 , 194.1 , 18.1 , 123.1 , 1.1 , 58.1 ,
                     223.1 , 218.1 , 81.1 , 187.1 , 145.1 , 30.2 , 73.1 ,
                      212.1 , 190.1 , 209.1 , 4.1 , 104.1 , 50.1 , 109.2 ,
                       210.1 , 162.2 , 183.1 , 35.1 , 12.2 , 179.1 , 89.1 ,
                        177.2 , 139.1 , 92.1 , 56.1 , 88.1 , 22.1 , 32.1 ,
                         172.1 , 156.1 , 158.1 , 121.1 , 149.1 , 17.2 , 25.1 ,
                          160.1 , 128.1 , 90.1 , 15.1 , 0.1 ,
                           null
                            null
                             null
                              null
                               null
                                217.1 ,
                                 null
                                  null
                                   227.1 , 225.1 ,
                                    null
                                     null
                                      299.1 , 288.1 , 277.1 , 234.1 , 272.1 , 261.1 , 254.1 ,
                                       293.2 , 283.1 , 281.1 , 241.2 , 243.2 , 275.1 , 260.1 ,
                                        289.1 , 267.1 , 274.1 , 237.1 , 258.1 ,
                                         null
                                          null

298.1 , 295.1 ,
null
null
305.1 , 302.1 ,
null
null
329.1 , 317.1 , 328.1 ,
null
null
366.3 , 355.2 , 365.1 , 343.1 , 341.1 , 335.2 , 363.1 ,
362.1 , 358.1 , 347.1 , 345.1 ,
null
null
null
478.2 , 458.1 , 438.1 , 420.1 , 393.1 , 392.1 , 399.2 ,
459.1 , 452.1 , 421.2 , 376.2 , 374.1 , 371.2 , 398.1 ,
456.1 , 390.2 , 442.1 , 380.1 , 381.1 , 384.1 , 439.1 ,
454.1 , 441.2 , 425.1 , 397.1 , 434.1 , 387.1 , 375.1 ,
400.1 ,
null
null
null
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477.1 , 466.1 , 473.2 , 461.1 ,
null
null
496.1 , 490.1 , 491.1 , 486.2 , 489.2 , 487.2 , 480.1 ,
493.1 ,
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null
511.1 , 510.1 , 499.1 , 506.2 , 503.1 ,
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553.1 , 549.1 , 538.1 , 533.1 , 534.1 , 522.1 , 518.1 ,
548.1 , 542.1 , 545.1 , 524.1 , 532.1 , 531.1 , 541.1 ,
529.1 , 520.1 ,
null
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null
null
562.1 , 561.1 ,
null
null

689.1 , 667.1 , 671.1 , 577.2 , 646.1 , 588.1 , 670.1 ,
686.1 , 654.1 , 662.3 , 628.1 , 621.1 , 605.1 , 615.2 ,
683.1 , 641.2 , 642.1 , 569.2 , 634.1 , 591.1 , 602.1 ,
673.1 , 656.1 , 660.2 , 566.2 , 611.1 , 603.1 , 658.2 ,
668.2 , 657.1 , 627.1 , 579.1 , 623.1 , 575.1 , 619.1 ,
664.2 , 620.1 , 659.1 , 604.1 , 595.1 , 609.1 , 643.1 ,
661.1 , 629.1 , 624.1 , 593.1 , 626.1 , 586.1 , 614.1 ,
649.1 ,
null
null
null
null
null
682.1 , 675.1 ,
null
null
null
null
747.1 , 736.3 , 721.2 , 727.1 , 735.1 , 710.1 , 705.1 ,
745.2 , 722.1 , 740.2 , 695.2 , 713.2 , 706.1 , 708.1 ,
734.1 , 731.1 , 725.1 , 716.1 , 726.1 , 690.1 , 724.1 ,
729.1 , 720.1 , 701.1 , 698.1 , 709.1 ,
null
null
739.1 ,
null
null
null
748.2 ,
null
null
753.2 ,
null
null
801.1 , 783.1 , 797.1 , 760.2 , 763.2 , 770.1 , 786.1 ,
791.1 , 785.1 , 789.2 , 773.1 , 779.1 , 769.1 , 776.1 ,
787.1 , 784.1 , 781.1 , 780.2 , 765.1 , 771.2 , 772.1 ,
null
null
800.1 , 796.1 , 798.1 ,
null
null
836.1 , 817.1 , 835.1 , 807.2 , 813.2 , 812.2 , 809.1 ,
833.1 , 832.2 , 824.1 , 804.2 ,

```
Items exist in tree:
Item: 665 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 870 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1345 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 2834 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 1309 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 4449 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1833 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 2941 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 2486 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1594 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 3856 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 1069 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 2393 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 2301 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 930 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 2262 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1063 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1187 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1949 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 3728 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 3249 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 363 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 2257 , Occurance in the array: 3 , Occurance in the tree: 3
Item: 896 , Occurance in the array: 4 , Occurance in the tree: 4
Item: 4206 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 4482 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1605 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 4549 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 2400 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 4076 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 2598 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 4954 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 4113 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 4030 , Occurance in the array: 3 , Occurance in the tree: 3
Item: 3939 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 3396 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 1198 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 1328 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 2981 , Occurance in the array: 2 , Occurance in the tree: 2
Item: 453 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 3186 , Occurance in the array: 3 , Occurance in the tree: 3
Item: 772 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 3170 , Occurance in the array: 1 , Occurance in the tree: 1
Item: 4214 , Occurance in the array: 2 , Occurance in the tree: 2

Items doesn't exist in tree:
Item: 5407 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5639 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5530 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5195 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5260 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5437 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5293 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5344 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5800 , Occurance in the array: 0 , Occurance in the tree: 0
Item: 5953 , Occurance in the array: 0 , Occurance in the tree: 0

Mode of the tree: 4678 Occurance in the array: 6 Occurance in the tree: 6

Removed item: 630      ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 710      ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 343      ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 223      ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 2627     ,        Before removal occurance: 2      ,        After removal: 1
Removed item: 2281     ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 1822     ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 381      ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 237      ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 2598     ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 2827     ,        Before removal occurance: 2      ,        After removal: 1
Removed item: 2343     ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 1287     ,        Before removal occurance: 2      ,        After removal: 1
Removed item: 3142     ,        Before removal occurance: 2      ,        After removal: 1
Removed item: 2041     ,        Before removal occurance: 1      ,        After removal: 0
Removed item: 2420     ,        Before removal occurance: 2      ,        After removal: 1
```

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Removed item: 2130      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 1857      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 1227      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 661       ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 2325      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 3261      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 490       ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 2953      ,      Before removal occurance: 3      ,      After removal: 2
Removed item: 309       ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 2313      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 1186      ,      Before removal occurance: 3      ,      After removal: 2
Removed item: 1639      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 1360      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 590       ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 3043      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 760       ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 1598      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 590       ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 854       ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 2318      ,      Before removal occurance: 3      ,      After removal: 2
Removed item: 2551      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 1272      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 2495      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 3285      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 36        ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 1847      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 2867      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 1506      ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 1655      ,      Before removal occurance: 1      ,      After removal: 0
Removed item: 421       ,      Before removal occurance: 2      ,      After removal: 1
Removed item: 3068      ,      Before removal occurance: 1      ,      After removal: 0


Trying to remove non-existing item: 5676      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5084      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5104      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5209      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5606      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5386      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5643      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5603      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5626      ,      Before removal occurance: 0      ,      After removal: 0
Trying to remove non-existing item: 5344      ,      Before removal occurance: 0      ,      After removal: 0
```