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CSCI2100 Assignment 3

Question 1

|  |  |  |  |
| --- | --- | --- | --- |
| A picture containing clock  Description automatically generated | After insert until node 9, the tree is right-right imbalanced, thus, left rotation on node 9 is used | A picture containing game, table, drawing  Description automatically generated | After update the height, the tree is balanced again |
| A close up of text on a black background  Description automatically generated | After insert until node 3, the tree is left-right imbalanced, thus, double rotation is used | A picture containing clock, drawing  Description automatically generated | After update the height, the tree is balanced again |
| A close up of text on a black background  Description automatically generated | After insert until node 7, the tree is left-right imbalanced, thus, double rotation is used | A close up of text on a white surface  Description automatically generated | After update the height, the tree is balanced again |
| A close up of text on a black background  Description automatically generated | The insertion is finished |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| A close up of text on a black background  Description automatically generated | Delete node 2 in the AVL tree | A close up of text on a black background  Description automatically generated | The AVL tree suffers from right-left imbalance, thus, double rotation is used |
| A close up of text on a black background  Description automatically generated | After update the height, the AVL tree is balanced again  The deletion is finished |  |  |

Question 2

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| --- | --- | --- | --- |
| A screenshot of a cell phone  Description automatically generated | After insert until node 5 with priority 7, it violates the max tree property, thus, move node 5 upward | A picture containing clock  Description automatically generated | After rotation, it still violates the max tree property, thus, move node 5 upward again |
| A picture containing clock, table  Description automatically generated | After rotation, there is no more violation | A picture containing drawing  Description automatically generated | After inset unitl node 11 with priority 8, it violates the max tree property, thus, mode node 11 upward |
|  | After rotation, it still violates the max tree property, thus, move node 11 upward again | A close up of a device  Description automatically generated | After rotation, there is no more violation  The insertion is finished |

|  |  |  |  |
| --- | --- | --- | --- |
| A picture containing clock  Description automatically generated | Attempt to delete node 7 with priority 16, we rotate node 2 , which has a larger priority, upward | A picture containing clock  Description automatically generated | Again, we rotate node 8 upward as it has the larger priority |
| A picture containing clock  Description automatically generated | We rotate node 5 with priority 9 upward | A close up of a logo  Description automatically generated | Node 7 became a leaf node, and we remove it |
| A picture containing clock  Description automatically generated | The deletion is finished |  |  |

Question 3

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A picture containing looking, clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 4 | 6 | 3 | 8 | 5 | 2 | 7 | 9 | | A picture containing clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 4 | 6 | 3 | 9 | 5 | 2 | 7 | 8 | | A picture containing clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 4 | 6 | 7 | 9 | 5 | 2 | 3 | 8 | |
|  |  |  |
| A picture containing clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 4 | 9 | 7 | 8 | 5 | 2 | 3 | 6 | | A picture containing clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 9 | 8 | 7 | 6 | 5 | 2 | 3 | 4 | |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A picture containing clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 9 | 8 | 7 | 6 | 5 | 2 | 3 | 4 | | A picture containing clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 8 | 6 | 7 | 4 | 5 | 2 | 3 | 9 | | A drawing of a person  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 7 | 6 | 3 | 4 | 5 | 2 | 8 | 9 | |
|  |  |  |
| A close up of a clock  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 6 | 5 | 3 | 4 | 2 | 7 | 8 | 9 | | A picture containing clock, table  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 5 | 4 | 3 | 2 | 6 | 7 | 8 | 9 | | A picture containing table  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 4 | 2 | 3 | 5 | 6 | 7 | 8 | 9 | |
|  |  |  |
| A picture containing game, table  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 3 | 2 | 4 | 5 | 6 | 7 | 8 | 9 | | A picture containing game  Description automatically generated   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |

Question 4

A picture containing drawing

Description automatically generated A picture containing drawing

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Description automatically generated

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 3 | 6 | 8 | 2 | 5 | 7 | 9 | | | | Temporary   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 |  |  |  |  |  |  |  | |
|  |  |  |
|  |  |  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 |  |  |  |  |  |  | |
|  |  |  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 |  |  |  |  |  | |
|  |  |  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 5 |  |  |  |  | |
|  |  |  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 5 | 6 |  |  |  | |
|  |  |  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 5 | 6 | 7 |  |  | |
|  |  |  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 5 | 6 | 7 | 8 |  | |
|  |  |  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 9 | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 6 | 3 | 5 | 2 | 7 | 4 | 1 | 8 | | Swap the pivot data and the last data |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 6 | 3 | 8 | 2 | 7 | 4 | 1 | 5 | |  |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 3 | 6 | 8 | 2 | 7 | 4 | 1 | 5 | |  |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 3 | 2 | 8 | 6 | 7 | 4 | 1 | 5 | |  |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 3 | 2 | 4 | 6 | 7 | 8 | 1 | 5 | |  |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 3 | 2 | 4 | 1 | 7 | 8 | 6 | 5 | |  |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | 3 | 2 | 4 | 1 | 5 | 8 | 6 | 7 | | Swap the last data and the data in nextsmallpos |

Question 5

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Array A   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 6 | 1 | 2 | 1 | 3 | 4 | 6 | 1 | 3 | 2 | | counter   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 3 | 2 | 2 | 1 | 0 | 2 | |
|  | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 3 | 5 | 7 | 8 | 8 | 10 | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Array B   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  | 2 |  |  |  |  |  | | counter   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 3 | 4 | 7 | 8 | 8 | 10 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  | 2 |  | 3 |  |  |  | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 3 | 4 | 6 | 8 | 8 | 10 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  | 1 |  | 2 |  | 3 |  |  |  | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 2 | 4 | 6 | 8 | 8 | 10 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  | 1 |  | 2 |  | 3 |  |  | 6 | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 2 | 4 | 6 | 8 | 8 | 9 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  | 1 |  | 2 |  | 3 | 4 |  | 6 | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 2 | 4 | 6 | 7 | 8 | 9 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  | 1 |  | 2 | 3 | 3 | 4 |  | 6 | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 2 | 4 | 5 | 7 | 8 | 9 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | 1 | 1 |  | 2 | 3 | 3 | 4 |  | 6 | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 1 | 4 | 5 | 7 | 8 | 9 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | 1 | 1 | 2 | 2 | 3 | 3 | 4 |  | 6 | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 1 | 3 | 5 | 7 | 8 | 9 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 |  | 6 | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 0 | 3 | 5 | 7 | 8 | 9 | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 6 | 6 | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 0 | 3 | 5 | 7 | 8 | 8 | |

Question 6

By counting sort, it builds up an array for counter. The sort cost (pre-processing time) is for integers are ranged in . The number of integers fall within a range of is , such algorithm takes time

Question 7

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  | | --- | | 4650 | | 7391 | | 5479 | | 3152 | | 2465 | | 3918 | | 9830 | | Sort on digit 1 | |  | | --- | | 4650 | | 9830 | | 7391 | | 3152 | | 2465 | | 3918 | | 5479 | | Sort on digit 2 | |  | | --- | | 3918 | | 9830 | | 4650 | | 3152 | | 2465 | | 5479 | | 7391 | | Sort on digit 3 | |  | | --- | | 3152 | | 7391 | | 2465 | | 5479 | | 4650 | | 9830 | | 3918 | | Sort on digit 4 | |  | | --- | | 2465 | | 3152 | | 3918 | | 4650 | | 5479 | | 7391 | | 9830 | |

1. We can represent numbers in range of with digit of base , such that , where . By radix sort, and , such that

Question 8

1. The expected number of the basic operation random(left,right) executed from Lines 1 to 7

, given that

For partition takes and others take constant time

Thus, the expected time complexity for Lines 1 to 7 is

the time complexity is