



CS202: FUNDAMENTALS OF COMPUTER SCIENCE

HOMEWORK - 4

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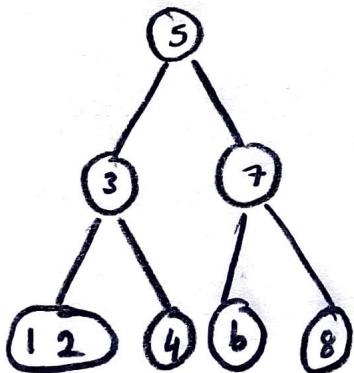
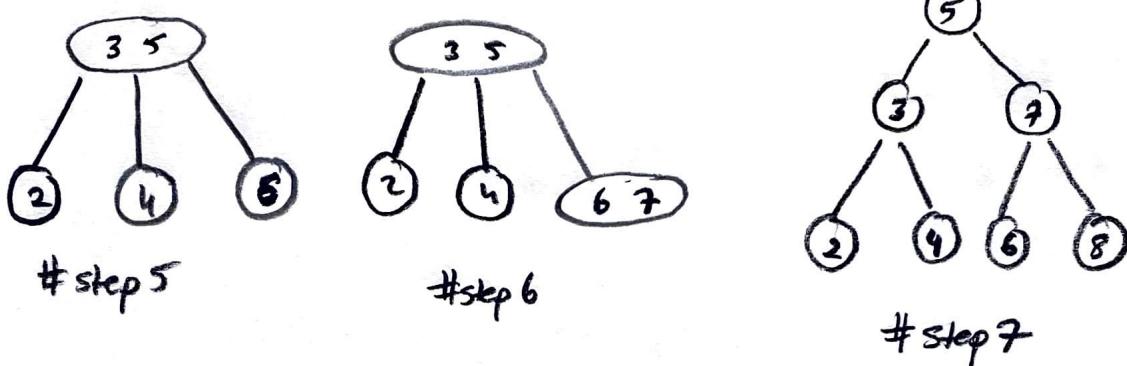
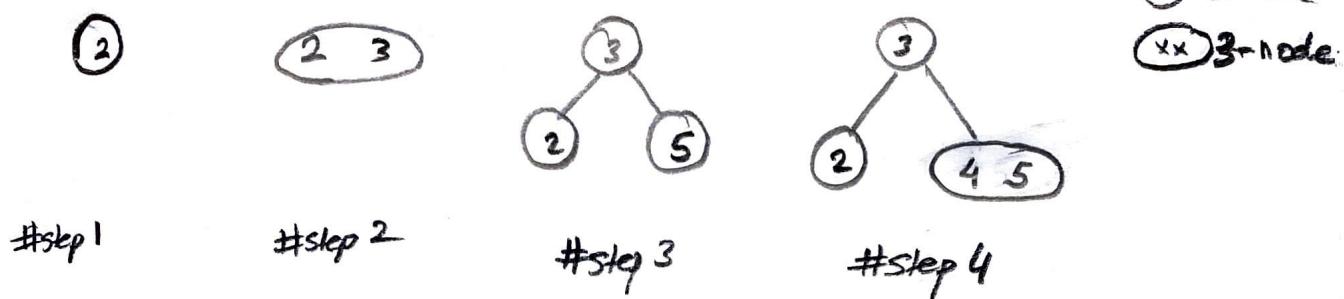
## Balanced Search Trees and Hashing

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Zeynep Begüm Kara  
ID: 22003880  
CS202 - 01

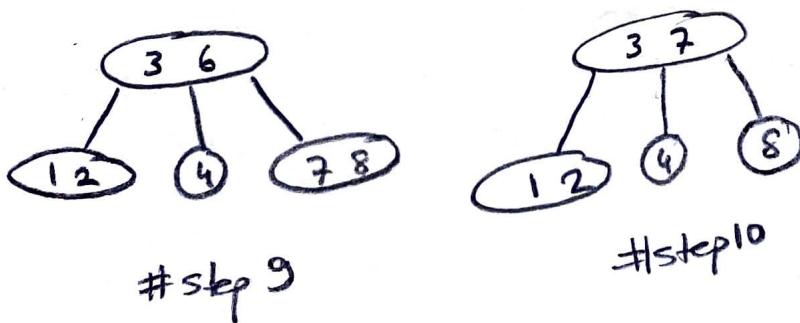
December 23, 2022

Q1] a) 2-3 Tree , inserting: 2 3 5 4 6 7 8 1 notation



#step 8

deleting: 5 6



Q1] b) 2-3-4 Tree, Inserting: 2 3 5 4 6 7 8 1

②

#step 1

2 3

#step 2

2 3 5

#step 3

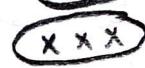
Notation



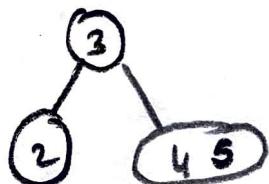
2-Node



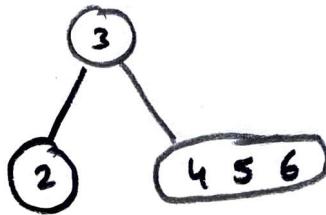
3-Node



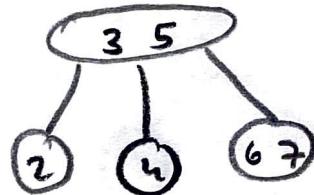
4-Node



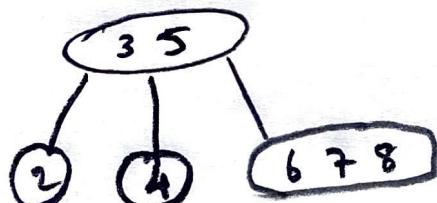
#step 4



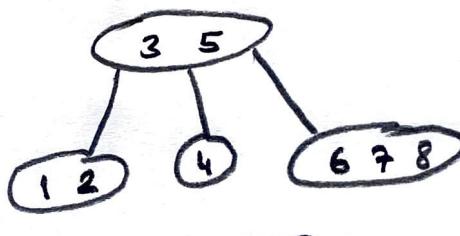
#step 5



#step 6

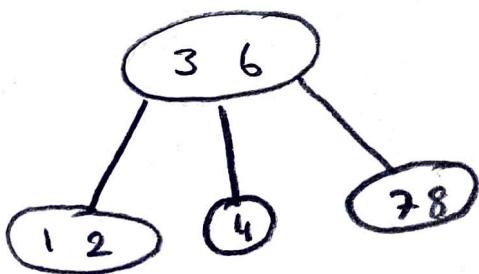


#step 7

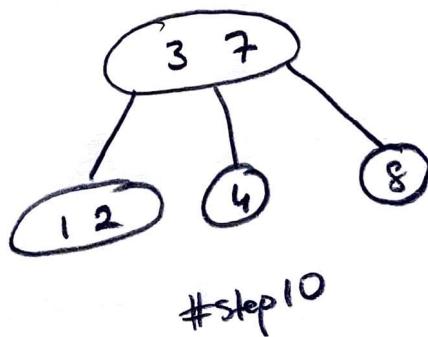


#step 8

deleting = 5, 6

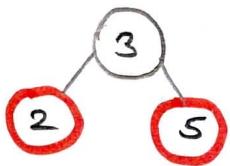


#step 9



#step 10

Q1 c) Red-Black Tree inserting: 2 3 5 4 6 7 8 1



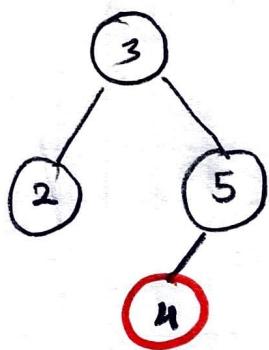
#step 1

#step 2

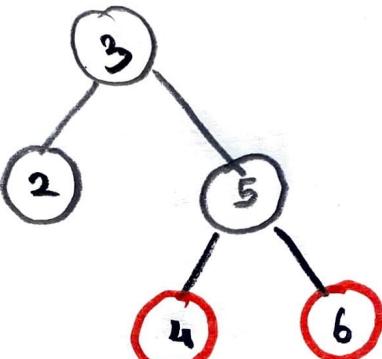
#step 3

rotation

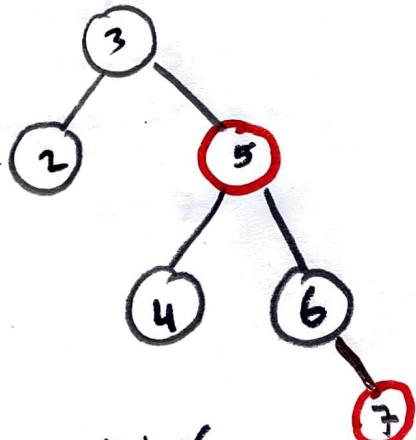
○ black node  
○ red node



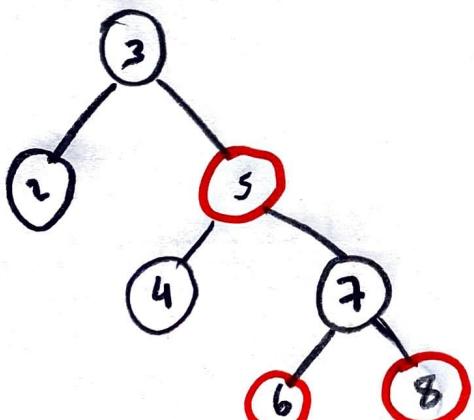
#step 4



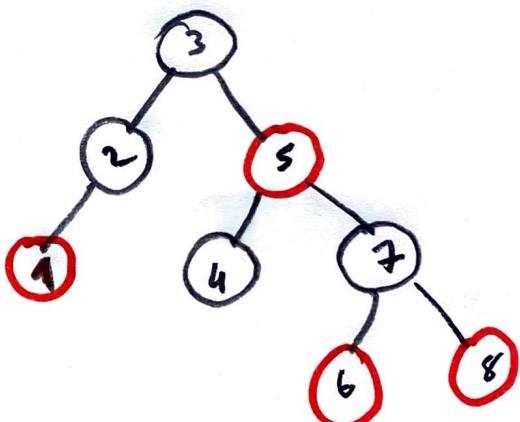
#step 5



#step 6



#step 7



#step 8

Q2] Hash Table with a size of 17 ,  $h(x) = x \bmod 17$

a) Open addressing with linear probing

0			34	34													
1																	
2	36	36	36	36	36	36	36										
3	20	20	20	20	20	20	20										
4	2	2	2	2	2	2	2										
5	19	19	19	19	19	19	19										
6	53	53	53														
7				37													
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
Step 1																	
Step 2																	
Step 3																	
Step 4																	
Step 5																	
Step 6																	
Step 7																	

keys : 20 36 2 19 53 34 37

$$20 \bmod 17 = 3$$

$$36 \bmod 17 = 2$$

$$2 \bmod 17 = 2, 2+1, 2+2 = 4$$

$$19 \bmod 17 = 2, 2+1, 2+2, 2+3 = 5$$

$$53 \bmod 17 = 2, 2+1, 2+2, 2+3, 2+4 = 6$$

$$34 \bmod 17 = 0$$

$$37 \bmod 17 = 3, 3+1, 3+2, 3+4 = 7$$

b) Open addressing with quadratic probing

0			34	34													
1					53	53	53										
2	36	36	36	36	36	36	36										
3	20	20	20	20	20	20	20										
4								37									
5																	
6	2	2	2	2	2	2	2										
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
Step 1																	
Step 2																	
Step 3																	
Step 4																	
Step 5																	
Step 6																	
Step 7																	

keys : 20 36 2 19 53 34 37

$$20 \bmod 17 = 3$$

$$36 \bmod 17 = 2$$

$$2 \bmod 17 = 2, 2+1^2; 2+2^2 = 6$$

$$19 \bmod 17 = 2, 2+1^2; 2+2^2, 2+3^2 = 11$$

$$53 \bmod 17 = 2, 2+1^2, 2+2^2, 2+3^2, 2+4^2 = 18 \text{ and } 18 \bmod 17 = 1$$

$$34 \bmod 17 = 0$$

$$37 \bmod 17 = 3, 3+1^2 = 4$$

c) Separate Chaining

0	→ 34   /
1	
2	→ 36   / → 2   / → 19   / → 53   /
3	→ 20   / → 37   /
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

Keys: 20 36 2 19 53 34 37

$$\begin{aligned}
 20 \bmod 17 &= 3 \\
 36 \bmod 17 &= 2 \\
 2 \bmod 17 &= 2 \\
 19 \bmod 17 &= 2 \\
 53 \bmod 17 &= 2 \\
 34 \bmod 17 &= 0 \\
 37 \bmod 17 &= 3
 \end{aligned}$$

Note that overlapping elements have been inserted at the end of the linked list.

resulting table