

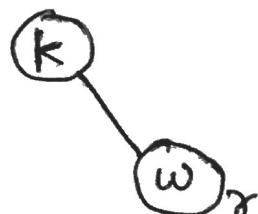
ASSIGNMENT #5

- ① Draw a red-black tree for the following values inserted in this order.
k w o s y t p x

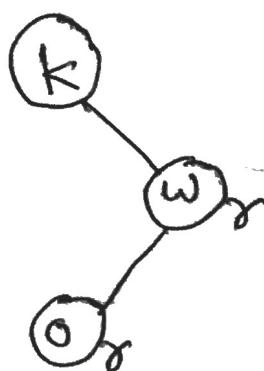
Insert k



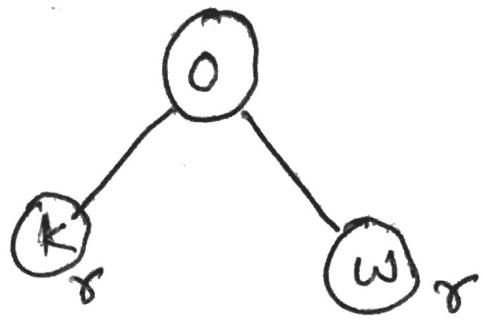
Insert w



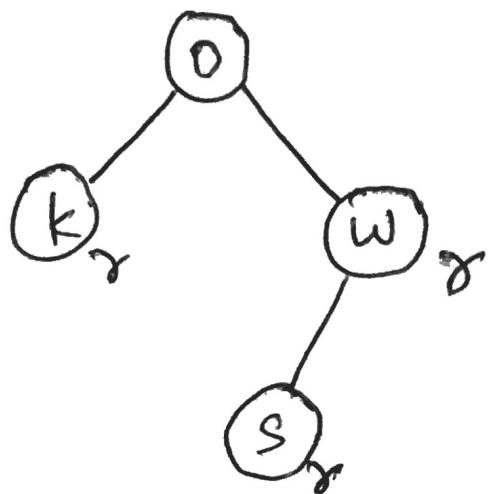
Insert o



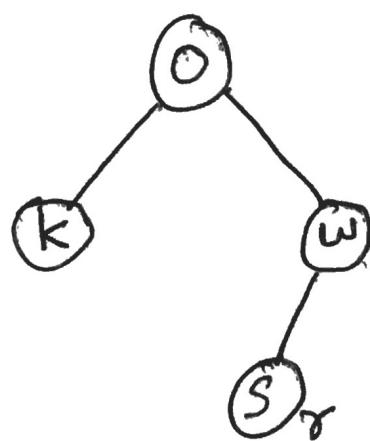
w has null sibling, therefore
restructure (zig-zag)



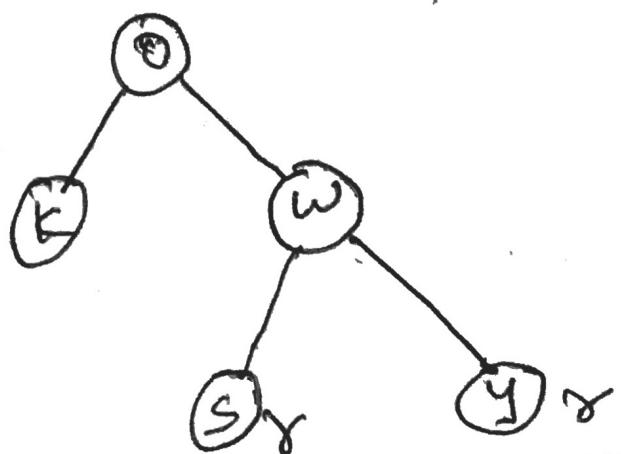
Insert s



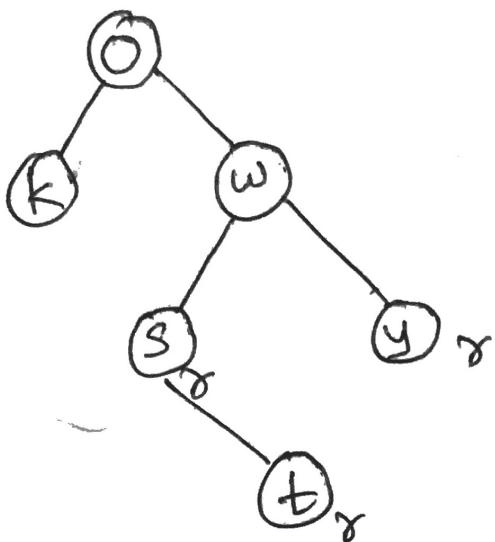
w has red sibling,
Recolor (root left black)



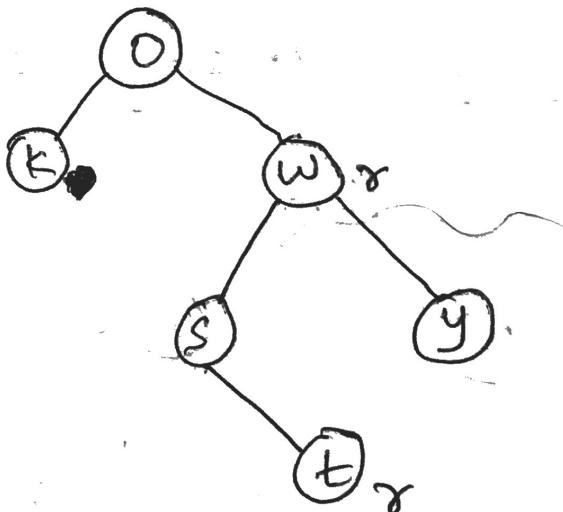
Insert y



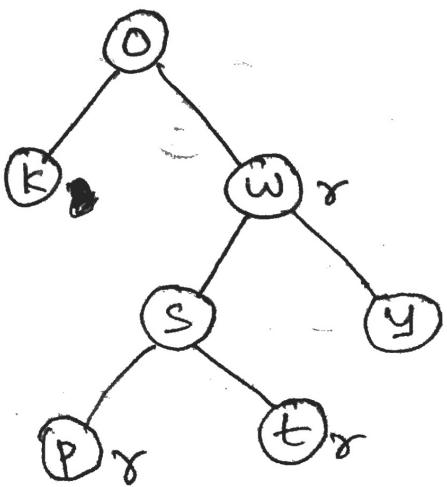
Insert t



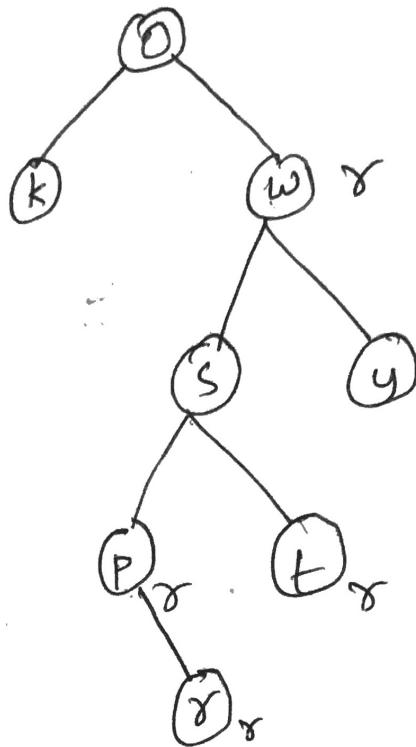
s has red sibling,
recolor



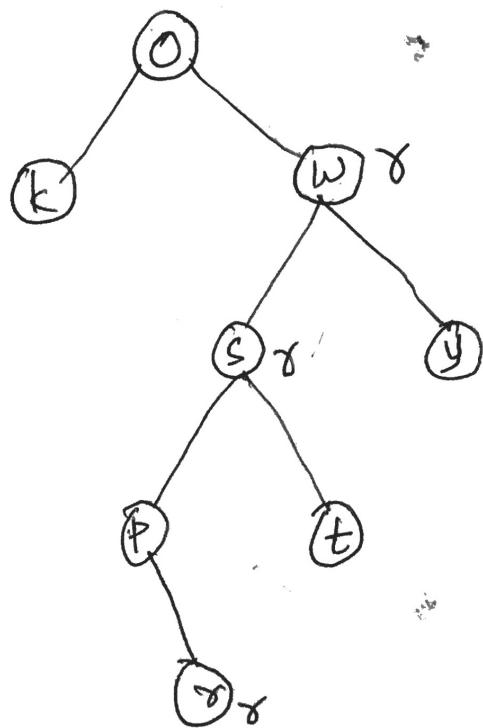
Insert p



Insert r

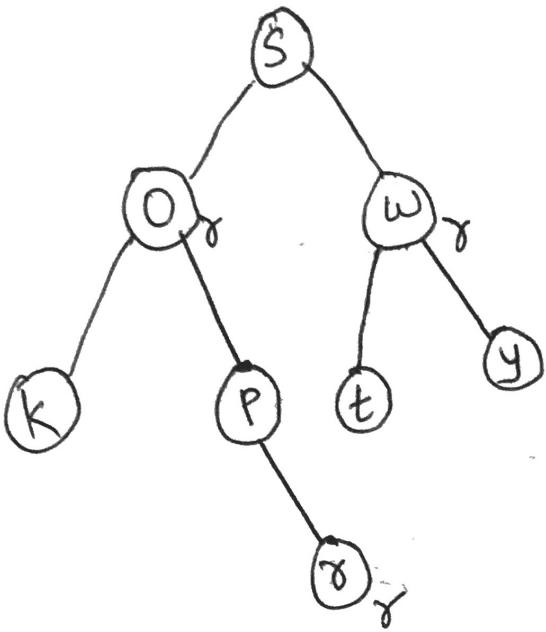


p has red sibling, recolor



w has black sibling,
restructure (zig-zag)

(2)



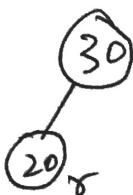
9

② 30 20 11 28 16 13 55 52 26 50 87

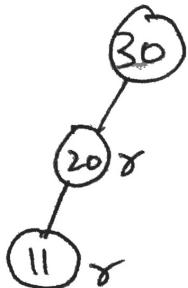
Insert 30



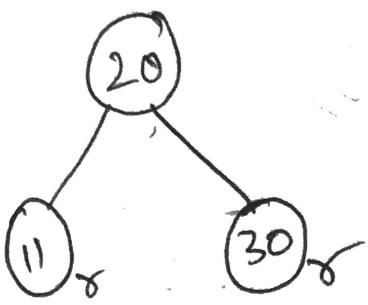
Insert 20



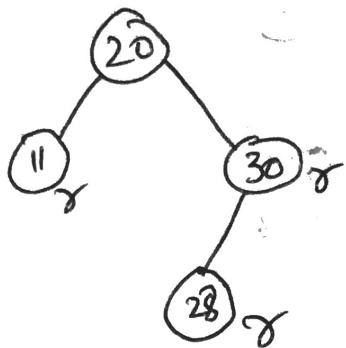
Insert 11



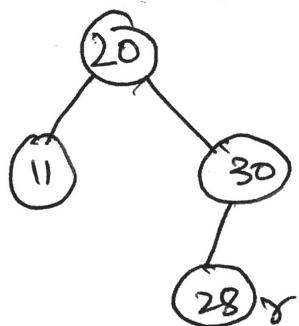
11 has no uncle i.e., 20 has null sibling,
restructure (zig-zig)



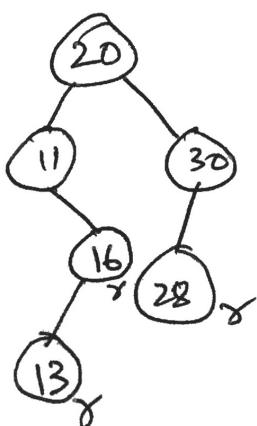
Insert 28



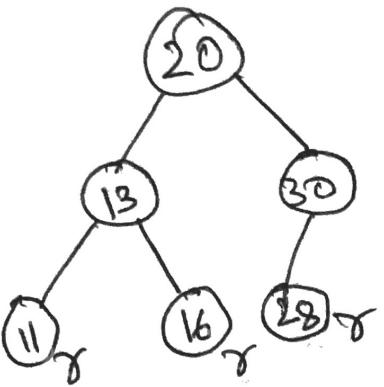
28 has red uncle, recolor



Insert 16, 13

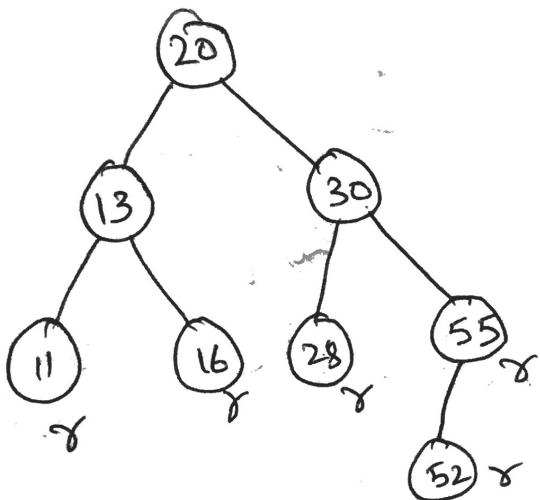


13 has null uncle, restructure
(zig-zag)

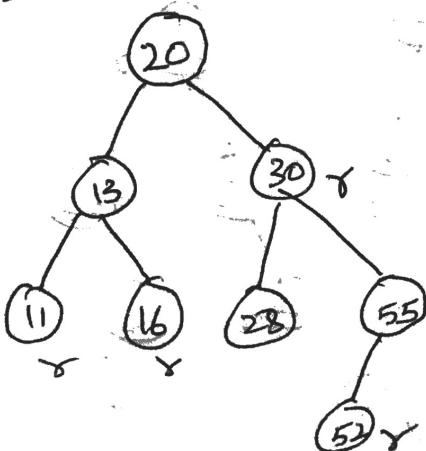


dfg

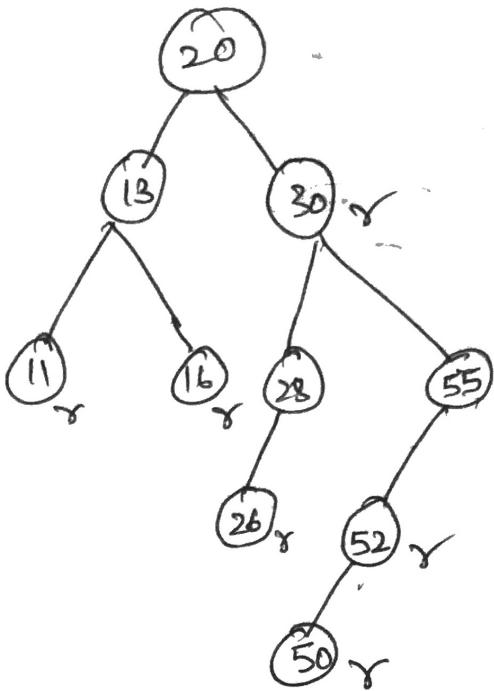
Insert 55, 52



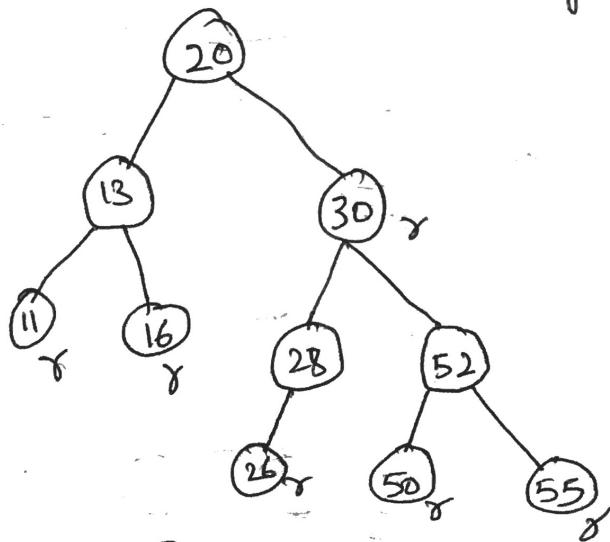
52 has red uncle, recolor



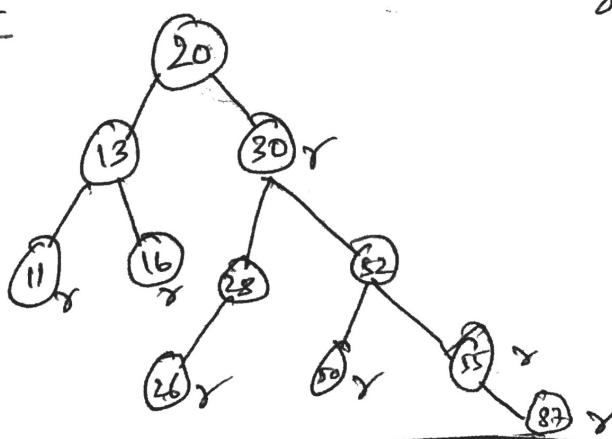
Insert 26, 50

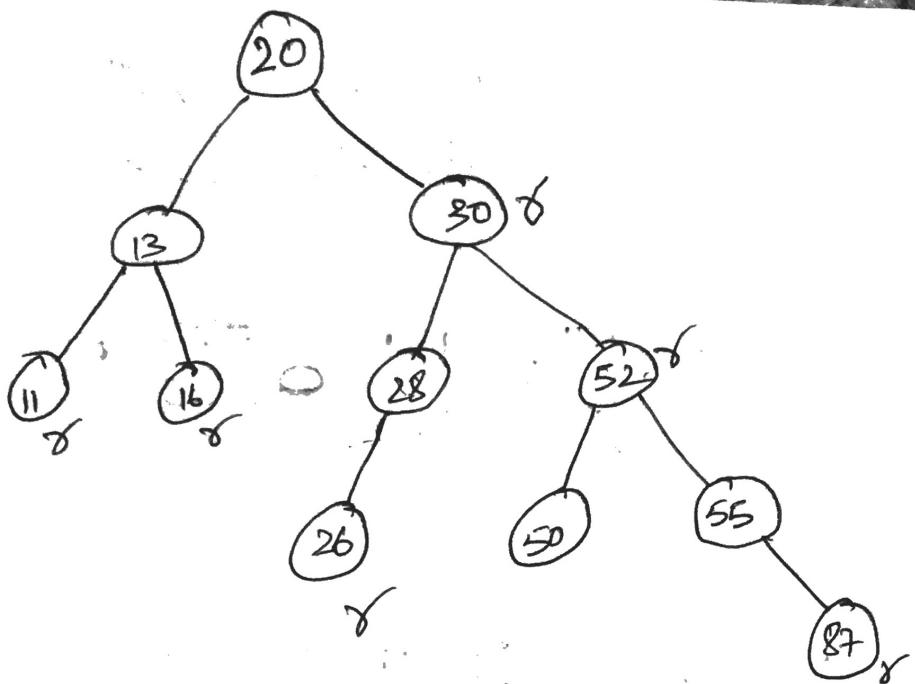


50 has null uncle, restructure
(zig-zig)

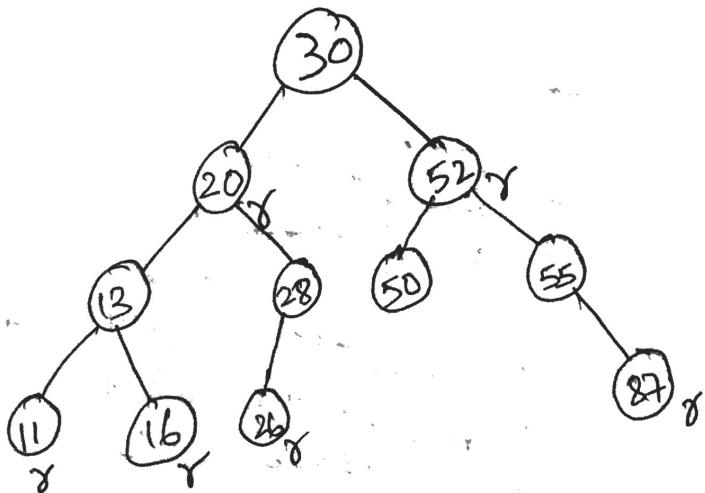


Insert 87

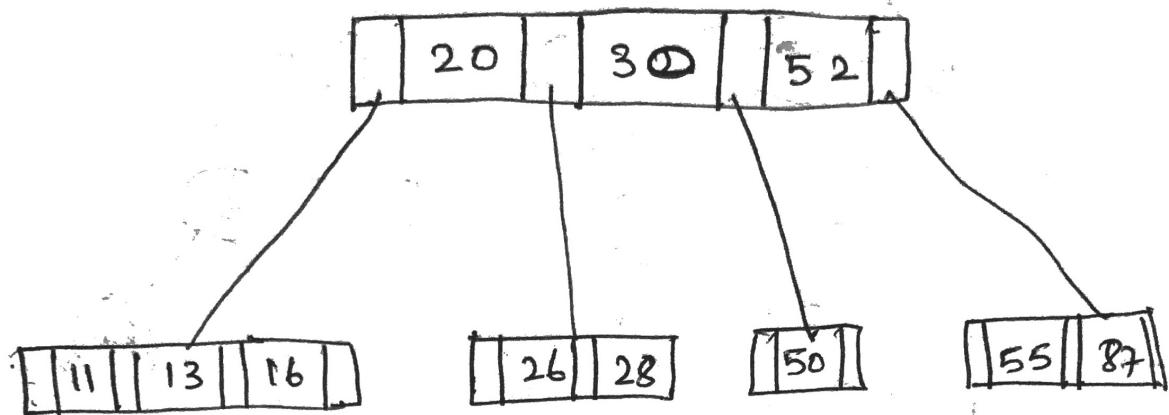




52 has black uncle, restructure
(zig-zig)

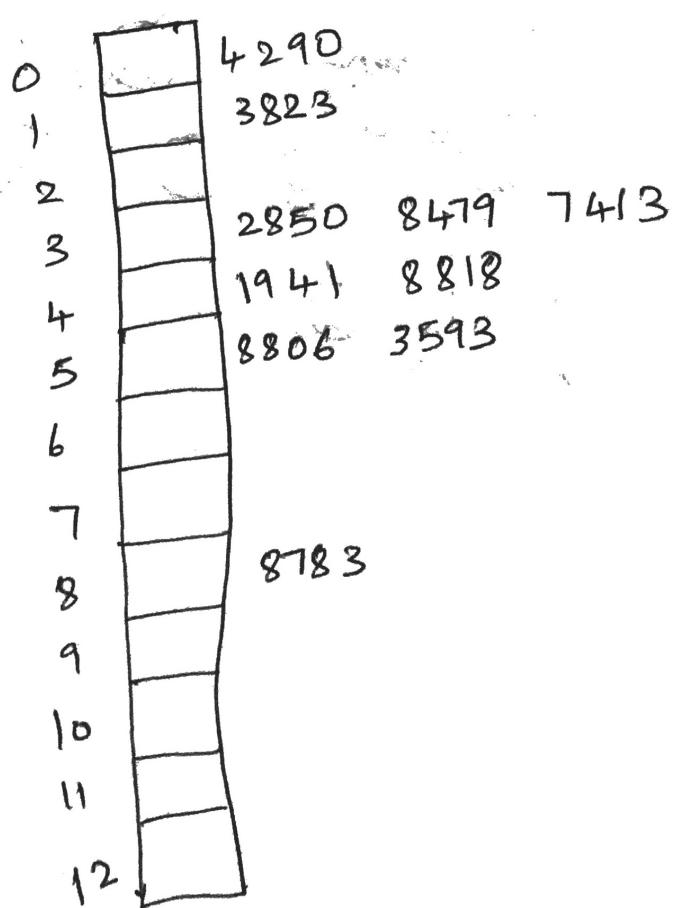


(3) 2-3-4 B-tree that corresponds to the above problem



(4) hash function $h(x) = x \bmod 13$

x	$h(x)$
3823	1
8806	5
8783	8
2850	3
3593	5
8479	3
1941	4
4290	0
8818	4
7413	3



⑤ Linear Probing

0	4290
1	3823
2	
3	2850
4	8479
5	8806
6	3593
7	1941
8	8783
9	8818
10	7413
11	
12	

⑥ Quadratic Probing

0	1941
1	3823
2	
3	2850
4	8479
5	8806
6	3593
7	1941
8	8783
9	8818
10	7413
11	
12	7413

⑦ Double hashing

$$h_2(x) = 11 - (x \bmod 11)$$

$h_1(x)$ $h_2(x)$

3823	1	5
8806	5	5
8783	8	6
2850	3	10
3593	5	4
8479	3	2
1941	4	6
4290	0	11
8818	4	4
7413	3	1

0	4290
1	3823
2	8479
3	2850
4	3593
5	8806
6	(1941)
7	8818
8	8783
9	7413
10	(8818)
11	(8818)
12	(4290)

0	4290
1	3823
2	8479
3	2850
4	3593
5	8806
6	1941
7	7413
8	8783
9	
10	
11	
12	8818

(8)

Bob 0100

Sue 1000

Tim 1110

Ron 0010

Ann 1010

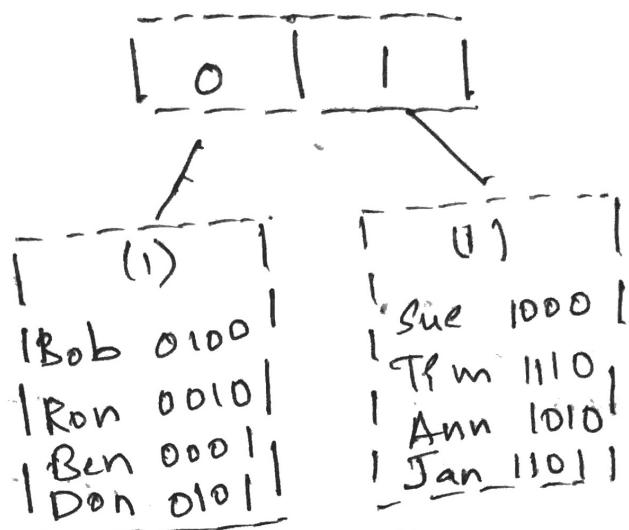
Jan 1101

Ben 0001

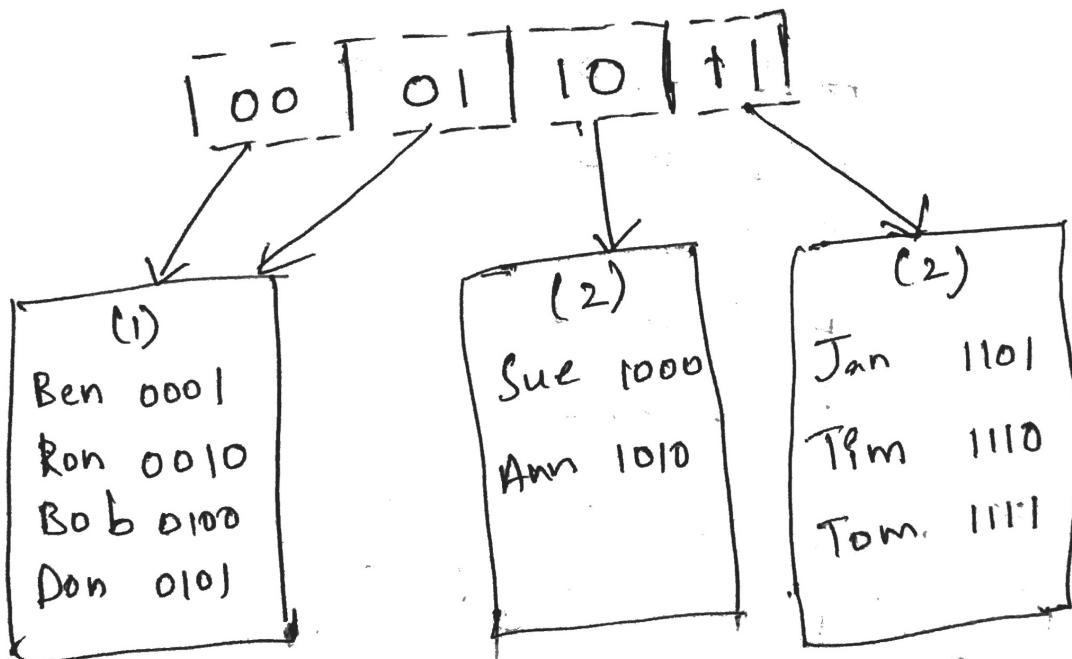
Don 0101

Tom 111

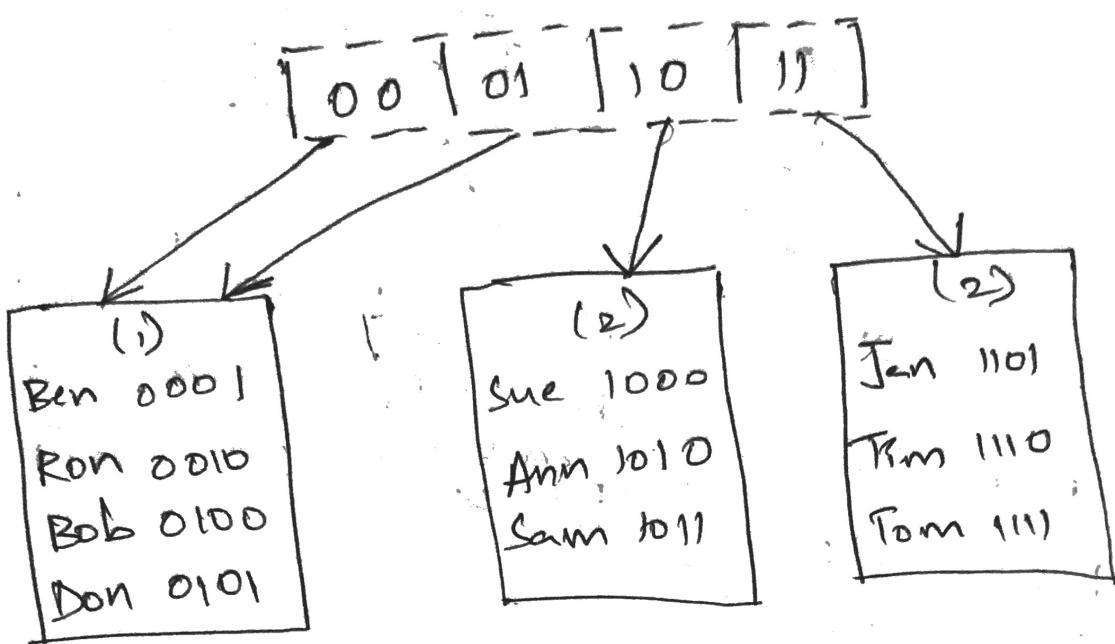
Sam 1011



Inserting Tom 1111 causes split,



Inciting Sam Lou,



⑨ Cuckoo Hash Table

$x : h_1(x), h_2(x)$

A : 1, 0

B : 0, 0

C : 4, 1

D : 0, 1

E : 2, 3

Table 1	
0	B
1	
2	A
3	
4	C

Table 2	
0	
1	
2	
3	
4	

A: 6
B: 7
C: 9
D: 7
E: 6
F: 7
G: 8

⑩

Inserting D

Table 1	
0	D
1	
2	A
3	
4	C

Table 2	
0	B
1	
2	
3	
4	

Inserting E

Table 1	
0	B
1	
2	E
3	
4	C

Table 2	
0	A
1	D
2	
3	
4	

⑩

Hopscotch

hashing

Maximum hop = 4

A: 6

B: 7

C: 9

D: 7

E: 6

F: 7

G: 8

Insert

	Item	Hop
0		0000
1		0000
2		0000
3		0000
4		0000
5		0000
6	A	1000
7	B	1000
8		0000
9	C	1000

Inserting D

	Item	Hop
0		
1		
2		
3		
4		
5		
6	A	1000
7	B	1100
8	D	0000
9	C	1000

Insert

Inserting E

After insertion

	Item	Hop
...		
6	A	1100
7	E	0101
8	D	0000
9	C	1000
10	B	0000
...		

Inserting F

	Item	Hop
...		
6	A	1100
7	E	0111
8	D	0000
9	F	0010
10	B	0000
11	C	0000
...		

Inserting G

	Item	Hope
...		
6	A	1100
7	E	0111
8	D	0000 F
9	F	0001
10	B	0000
11	G	0000
12	C	0000
...		

1110