Insertion into a B-tree.

(We assume search keys are unique, i.e: key attribute(s)).

Insert Algorithm: (insert x). → (x, pointer to x)

(1) Find the leaf node L where search key x belongs.

(2) If leaf node L has an empty slot:

(A) shift keys to make room for x

(B) insert x and the record address of x

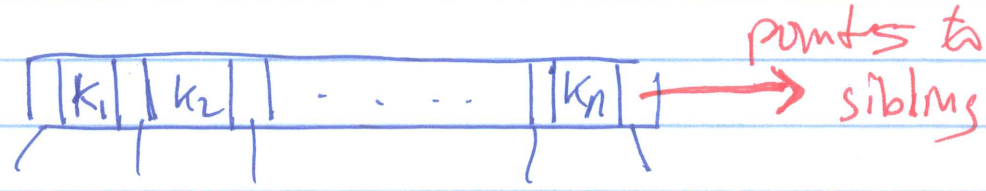
DONE.

(3) If leaf node L is full:

See next page.

(3) If leaf node L is full:

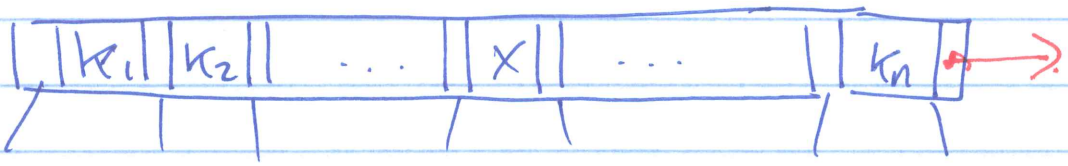
(A)



(L) must have

n	keys
$n+1$	pointers.

Including (X, pointer to X). We have:



We have: $n+1$ keys.

$n+2$ pointers.

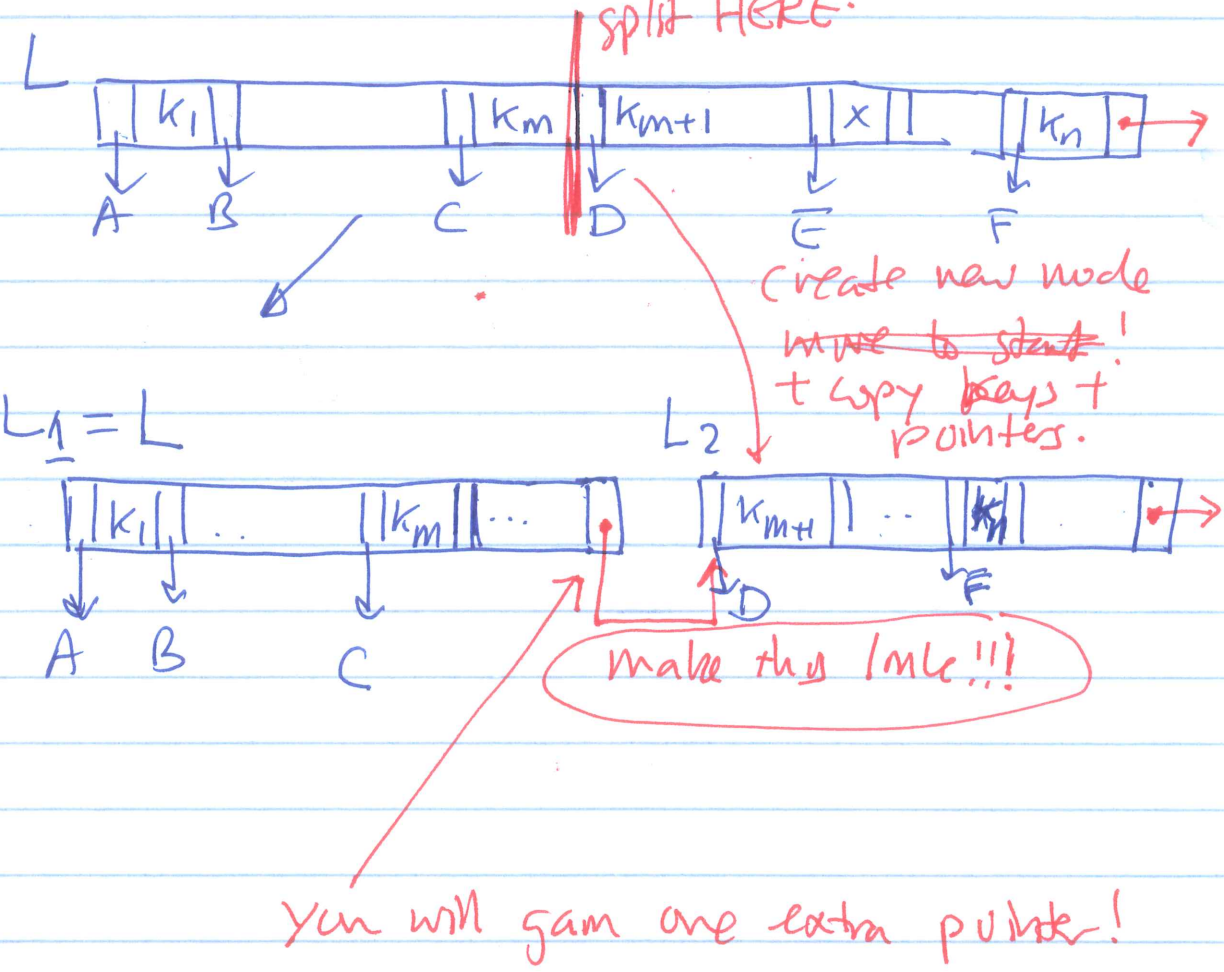
(B) Split the node in half:

(see next page)

Let $m = \lceil \frac{n}{2} \rceil$

$n=3, m=2$
$n=4, m=2$
$n=5, m=3$
$n=6, m=3.$

(B) split the node in half:



(C) Insert (K_{m+1}, L_2)

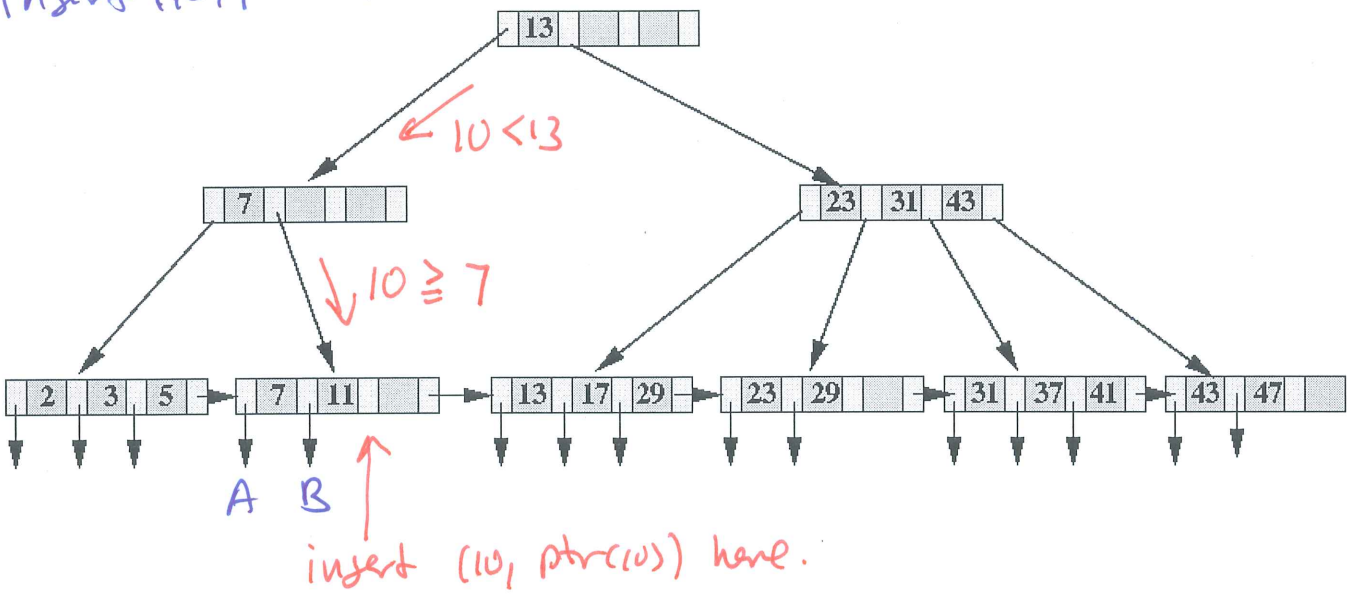
into the parent node of L.

(The parent node can split!!!

→ cascade to leaf!!!

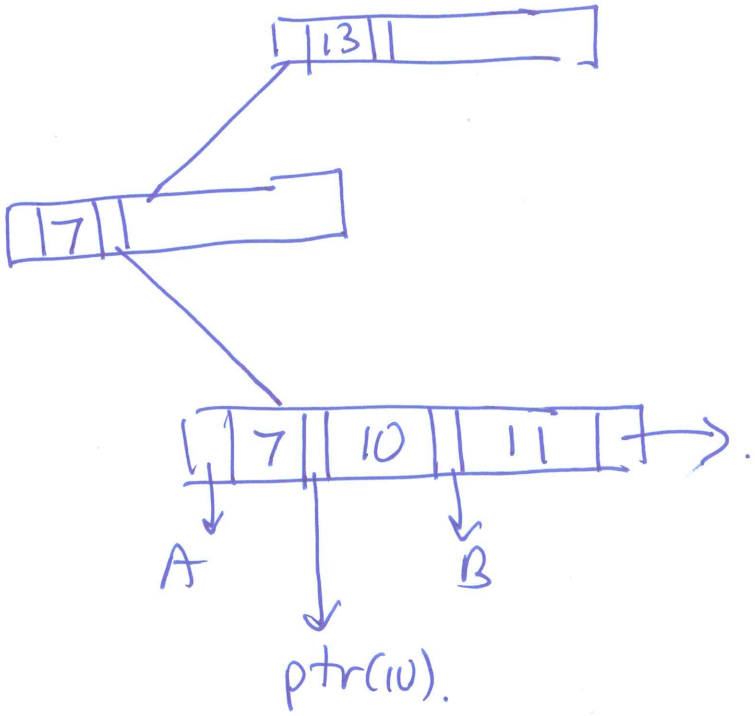
Insert case 1: leaf node has space

Insert (10, ptr(10))

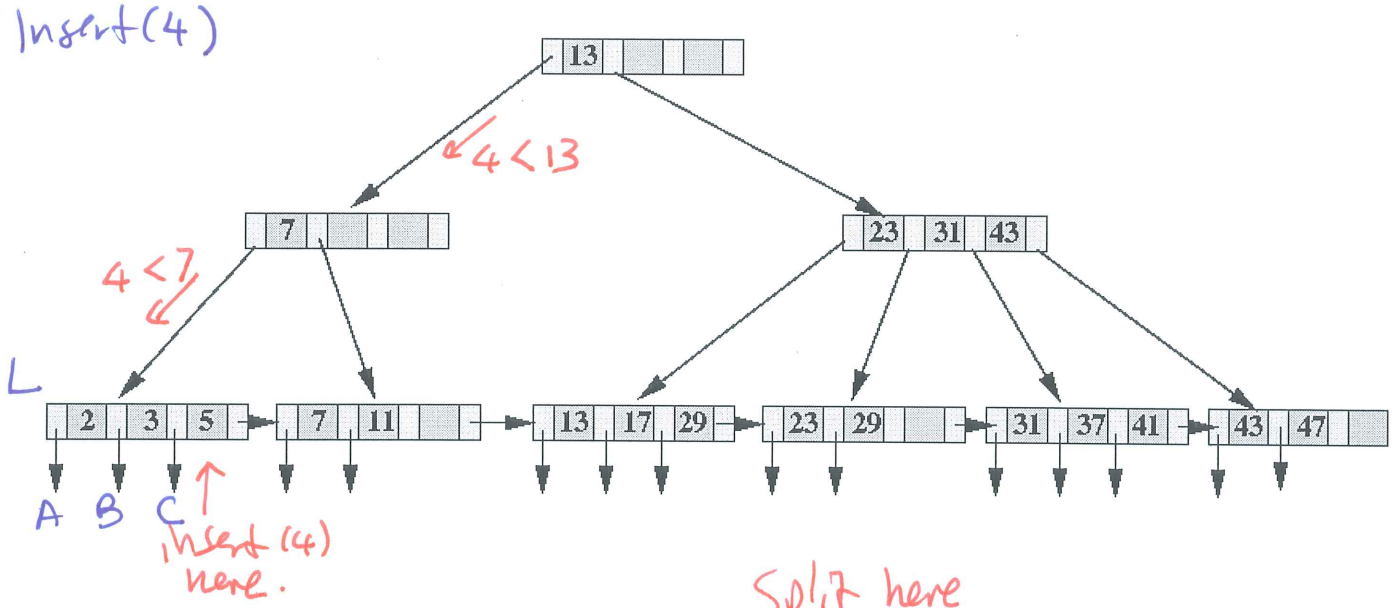


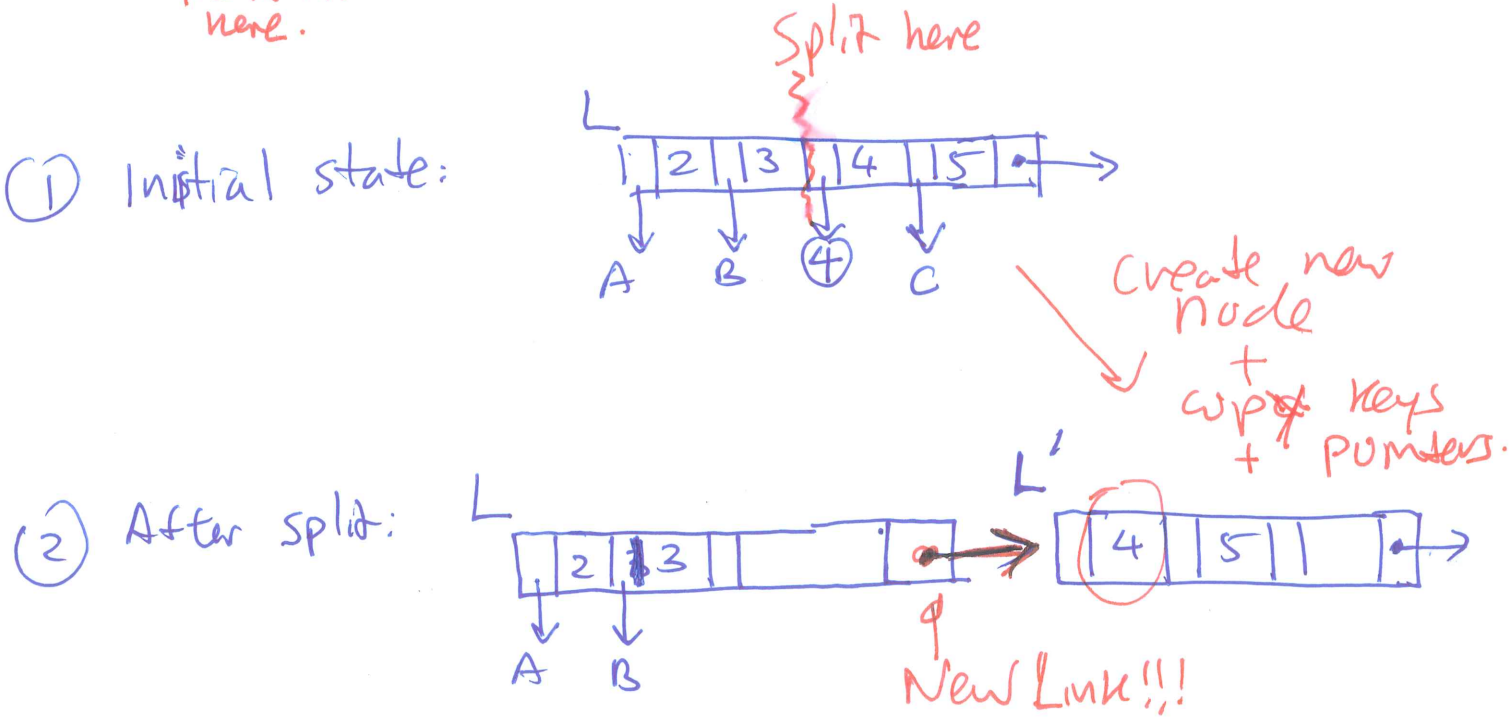
Result:

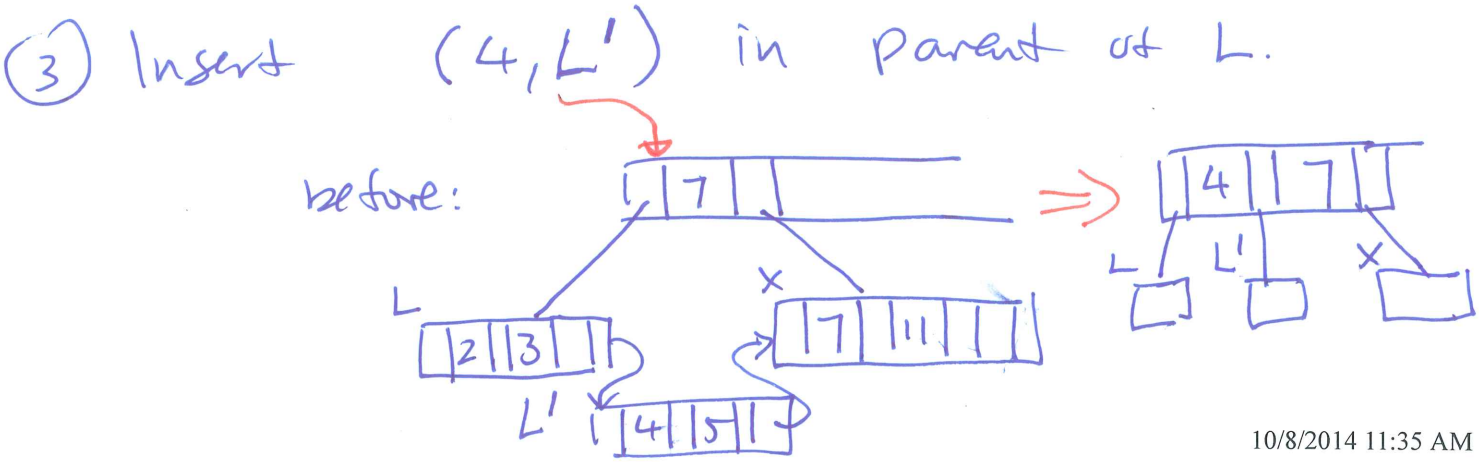
(use board!)



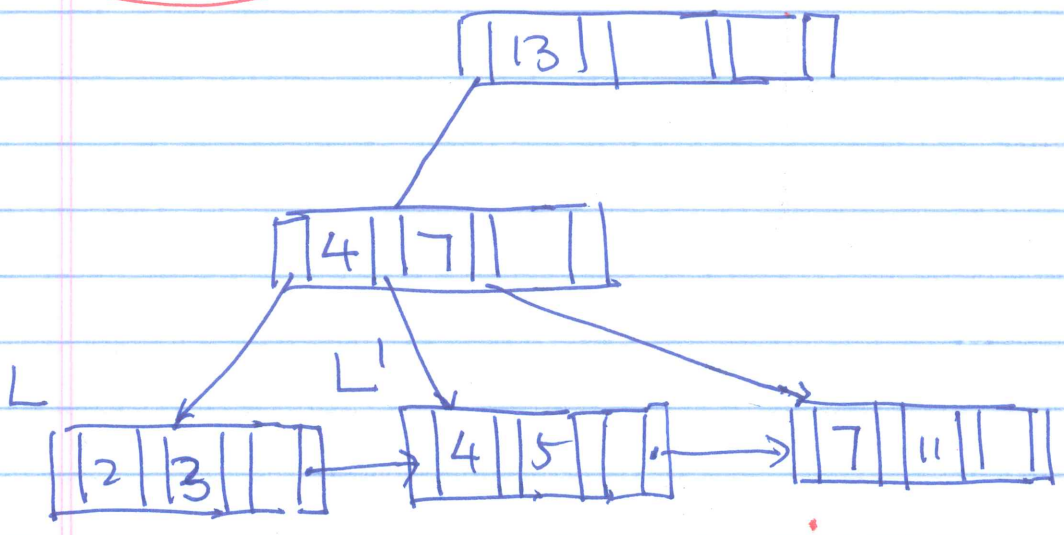
Insert case 2: cascade 1 level





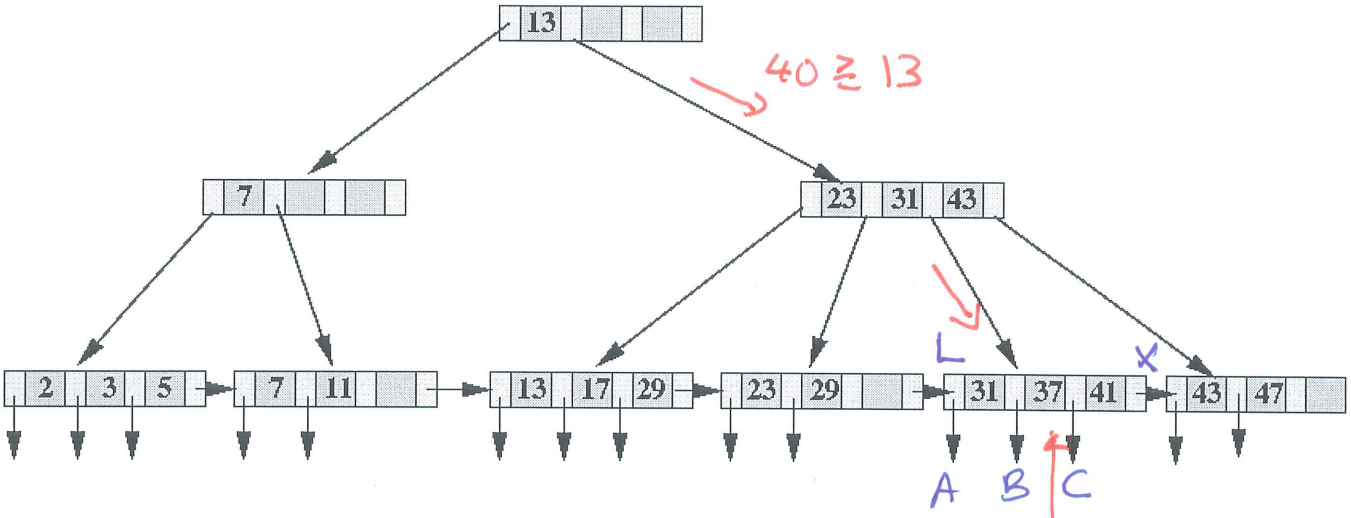


Result:

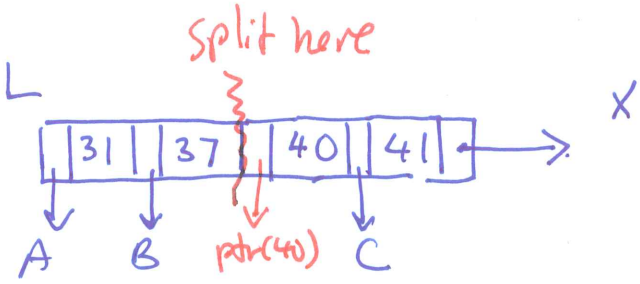


Insert case 3: cascade insert multiple levels

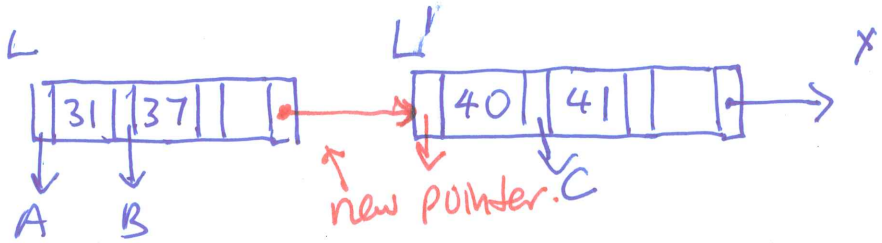
insert (40, ptr(40))



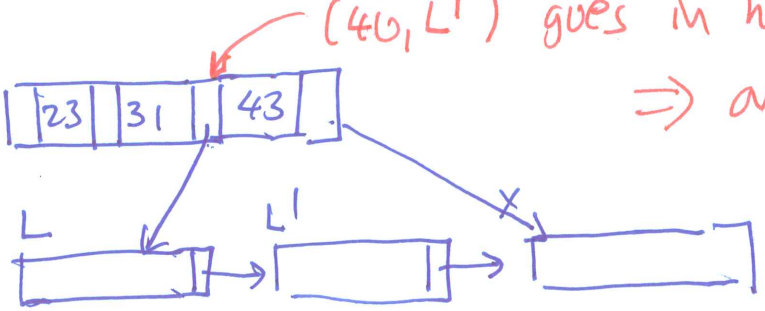
(1) Initial state:



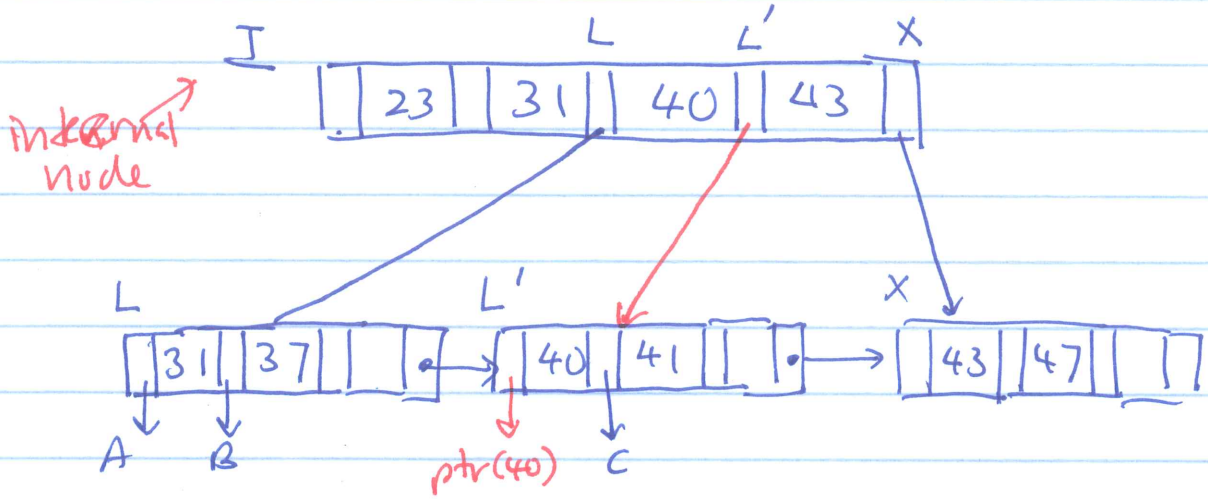
(2) After split:



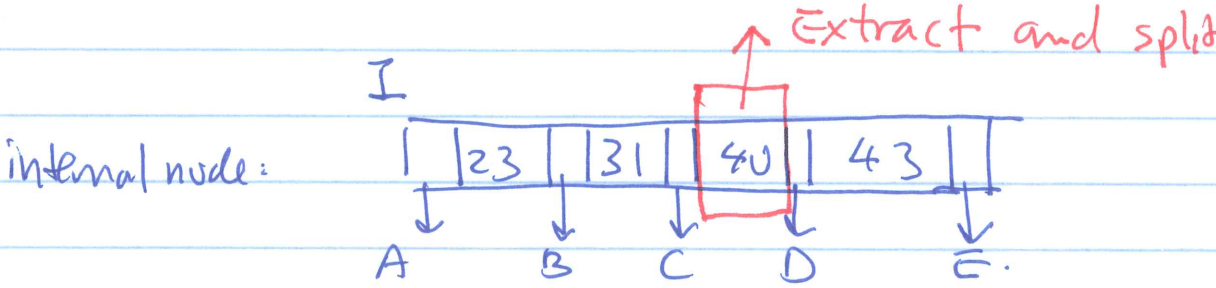
(3) Insert (40, L') in parent of L.



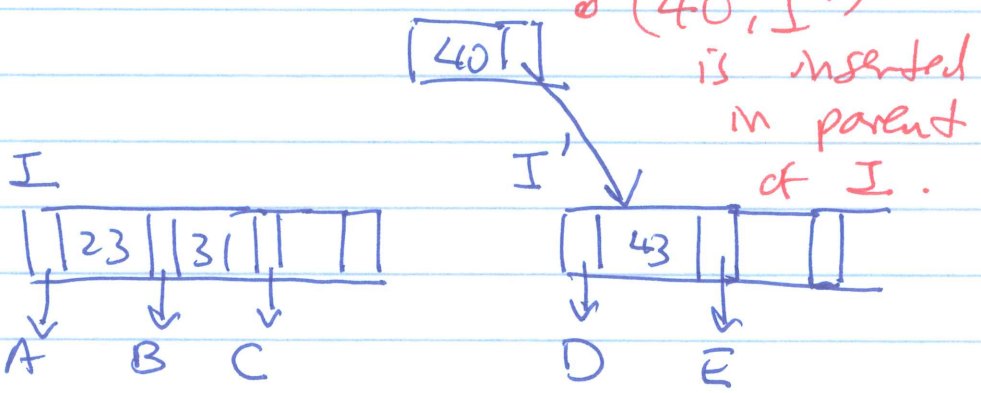
(4) initial state after inserting (40, L'):

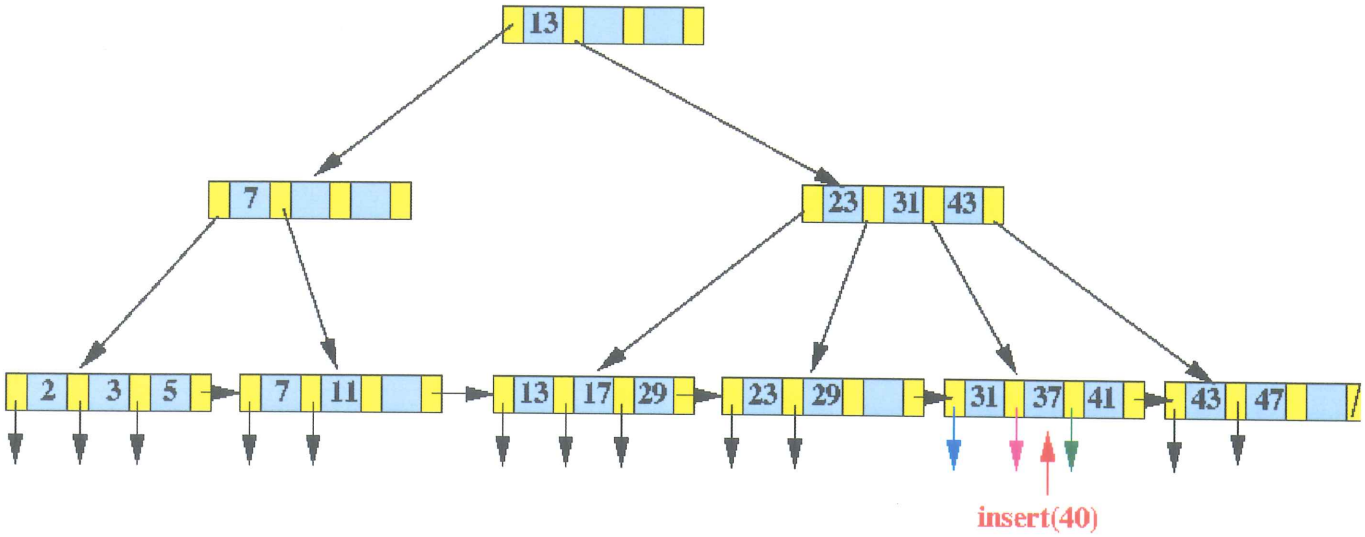


Split internal node is different: (diff. procedure)



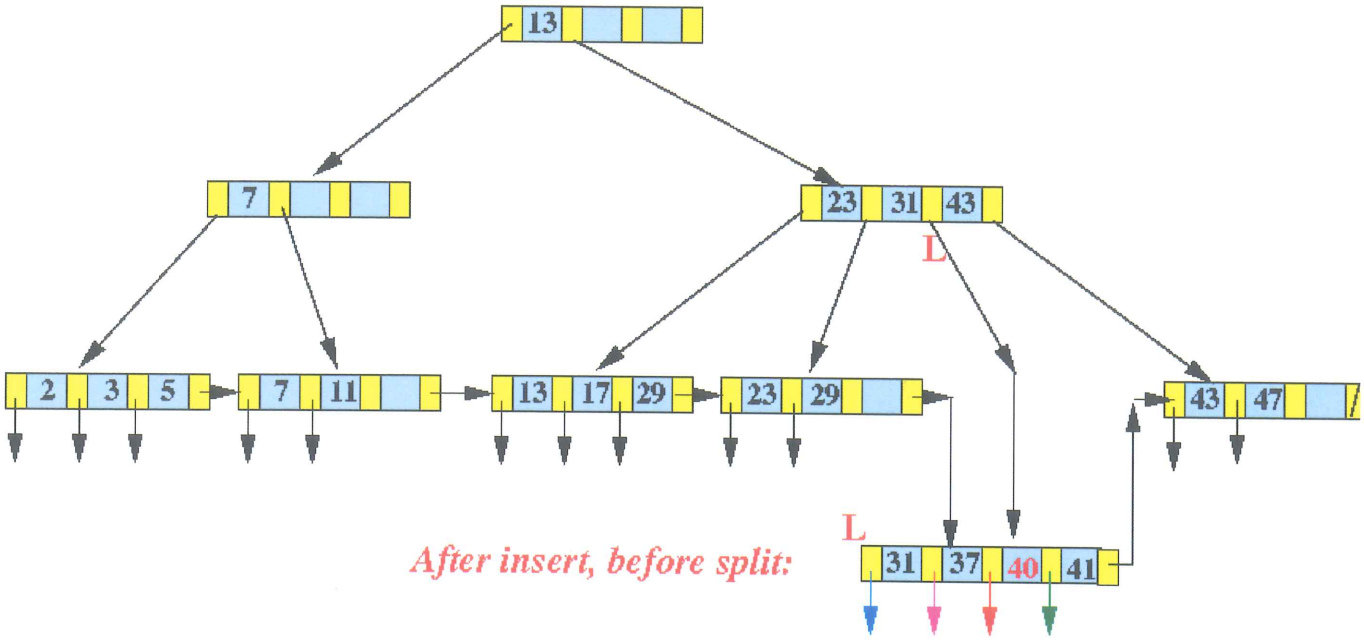
After split:

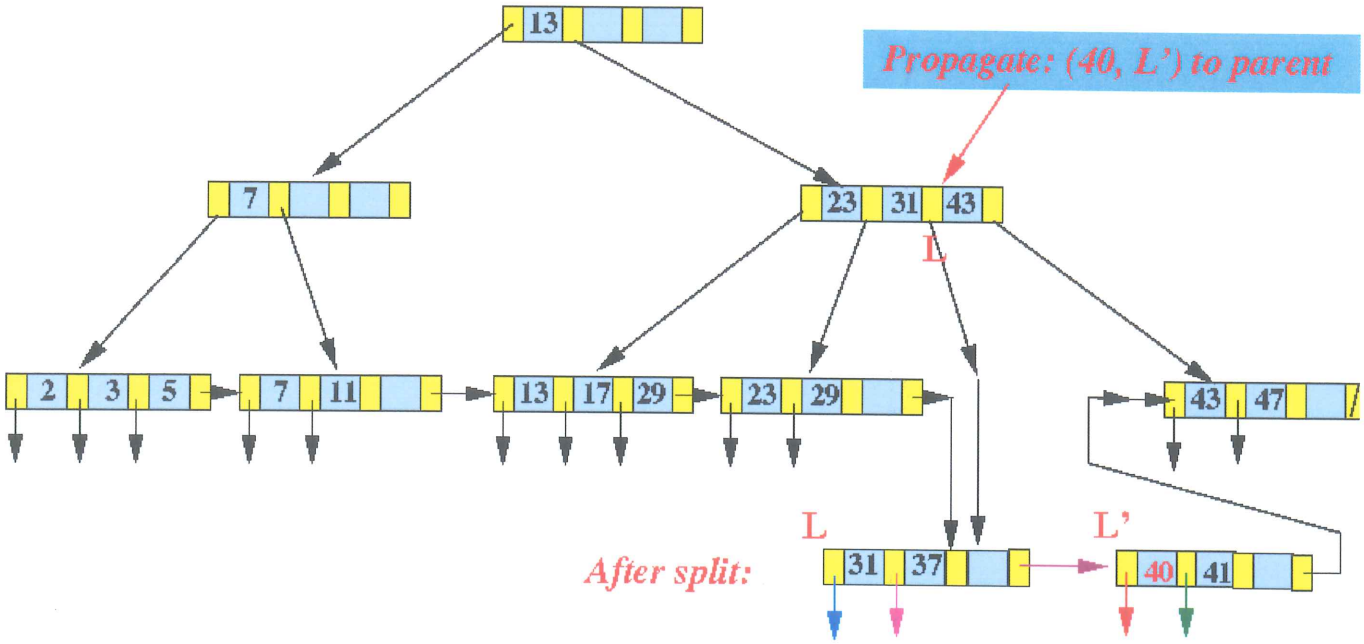


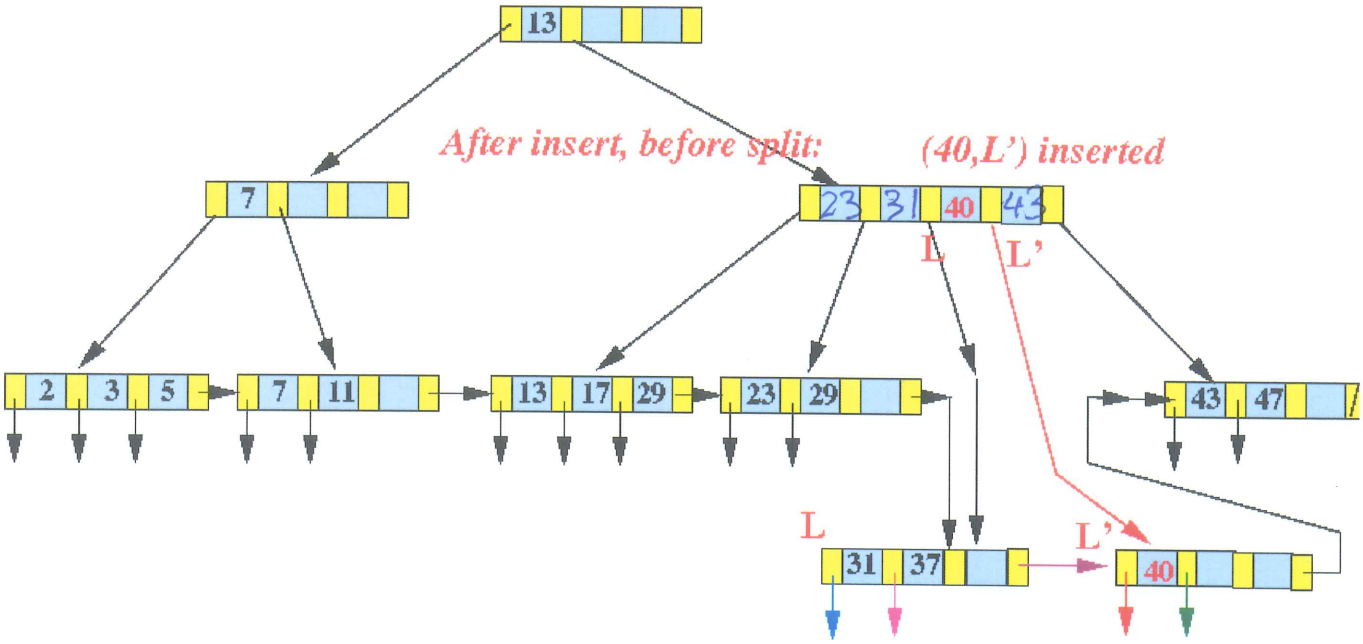


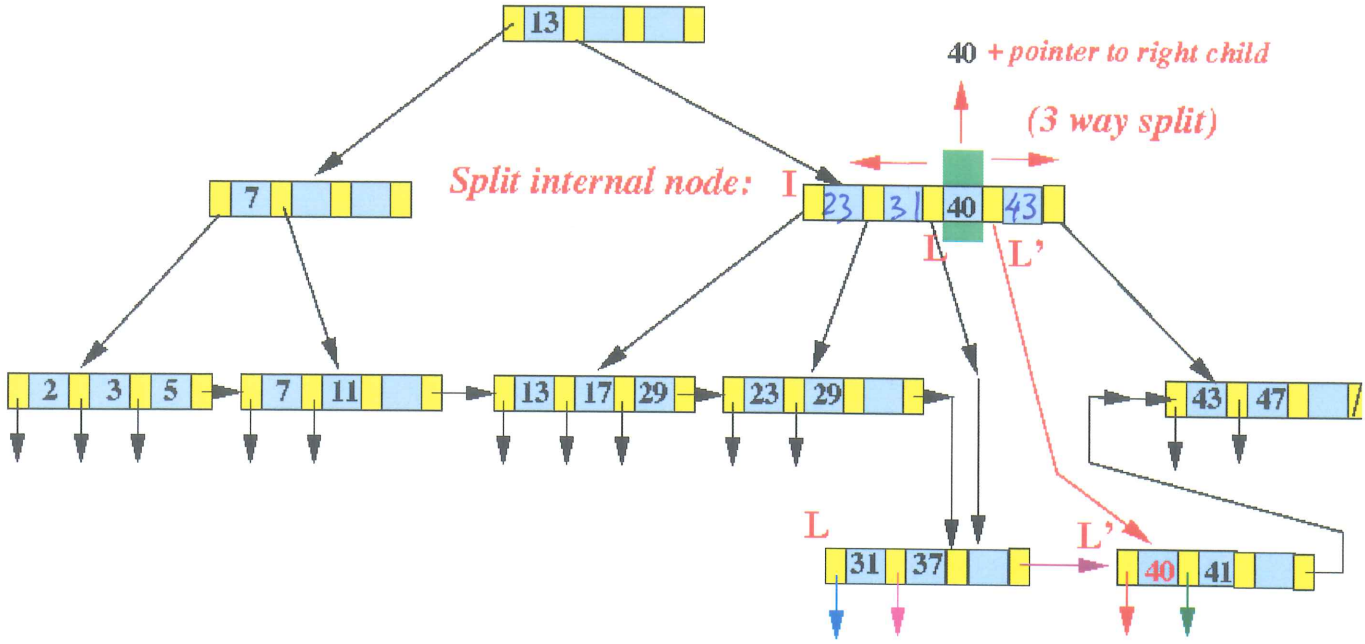
Worked out example

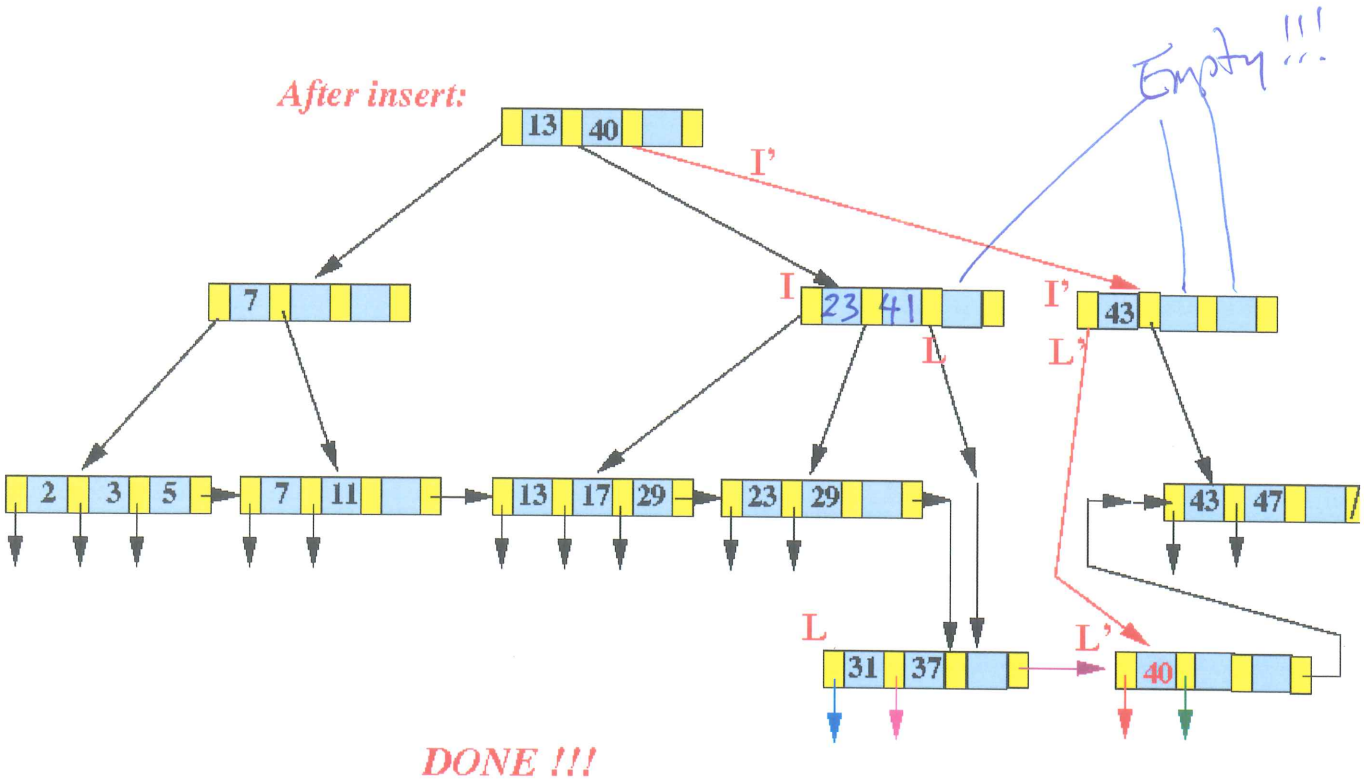
(show with board!?)


13
7
23
31
43
L
2
3
5
7
11
13
17
29
23
29
43
47
L
31
37
40
41
After insert, before split:


13
Propagate: (40, L') to parent
7
23 31 43
L
2 3 5
7 11
13 17 29
23 29
43 47
L
L'
After split:
31 37
40 41


13
After insert, before split:
(40,L') inserted
7
23 31 40 43
L
L'
2 3 5
7 11
13 17 29
23 29
43 47
L
L'
31 37
40


13
40 + pointer to right child
(3 way split)
Split internal node: I
7
23
31
40
43
L
L'
2
3
5
7
11
13
17
29
23
29
43
47
L
L'
31
37
40
41


After insert:
13
40
I'
Empty !!!
7
I
23
41
I'
43
L
L'
2
3
5
7
11
13
17
29
23
29
43
47
L
L'
31
37
40
DONE !!!