

Sabbir Ahmed,
HW 5 - Version B

Section: 02

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① Build a B-tree with the following (max degree = 5)

44, 30, 3, 80, 66, 51, 5, 67, 95, 14, 22, 82, 2, 40, 98

insert 44:

44

insert 30:

30	44
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 ∵ $30 < 44$

insert 3:

3	30	44
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 ∵ $3 < 30 < 44$

insert 80:

3	30	44	80
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 ∵ $80 > 44$

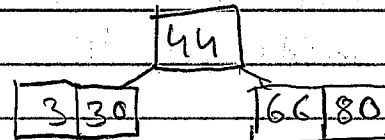
insert 66:

3	30	44	66	80
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 ∵ $44 < 66 < 80$

split the node, ∵ degree = 5

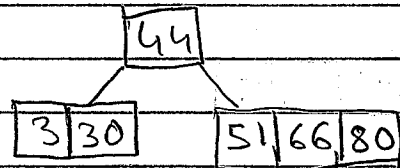
promote middle key, 44



insert 51:

44

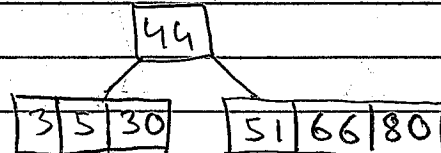
 ∵ $51 > 44, 51 < 66$



insert 5:

44

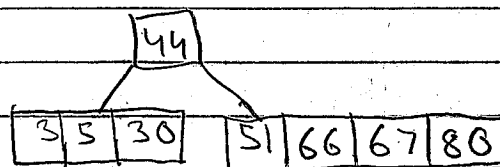
 ∵ $5 < 44, 3 < 5 < 30$



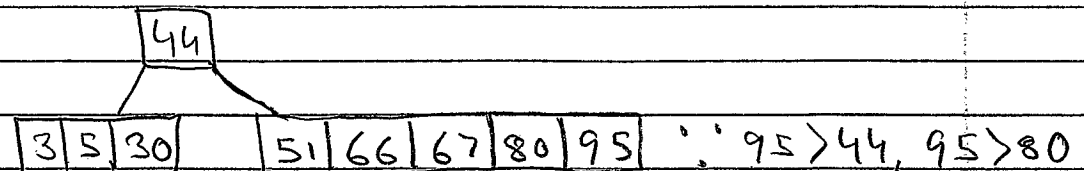
insert 67:

44

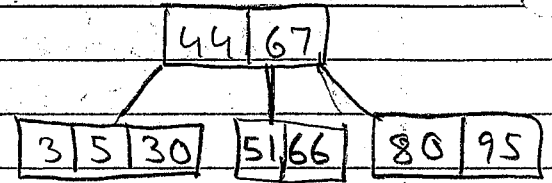
 ∵ $67 > 44, 66 < 67 < 80$



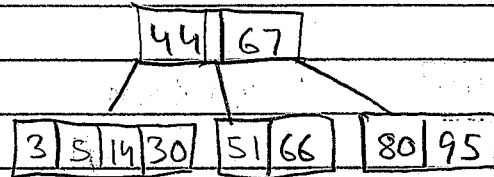
insert 95:



∴ degree of the node = 5, split it
 promote the middle key, 67
 ∴ $67 > 44$, 67 is right of 44

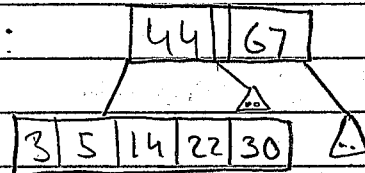


insert 14:



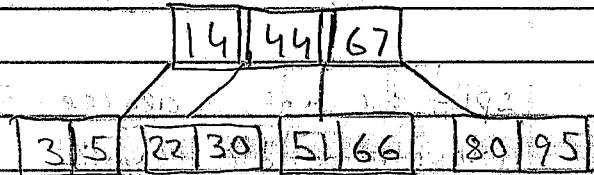
∴ $14 < 44$, $5 < 14 < 30$

insert 22:

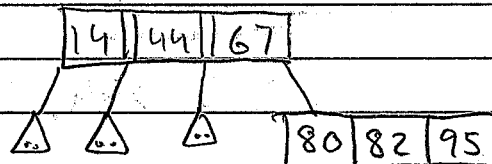


△ := unaffected subtrees

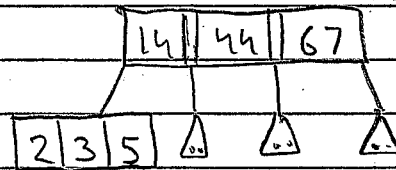
∴ degree of node = 5, split
 promote middle key, 14



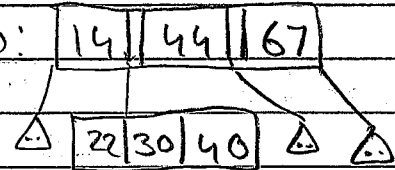
insert 82:



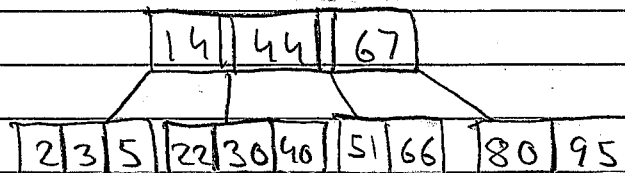
insert 2:



insert 40:

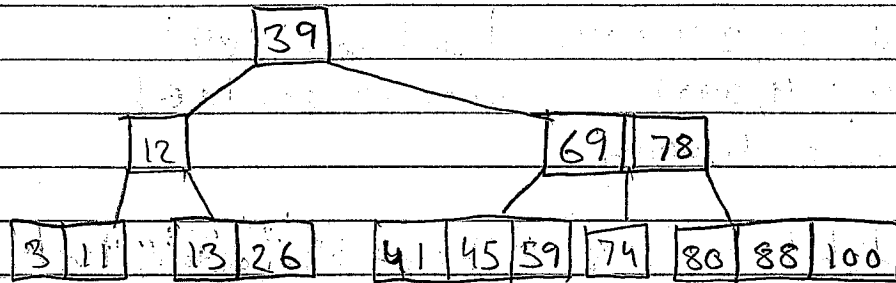


insert 98:

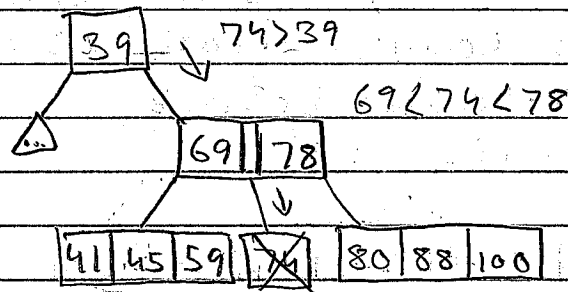


Final B-tree

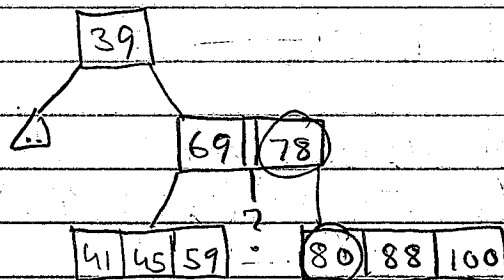
② Delete 74 from the B-tree with a max degree of 4.



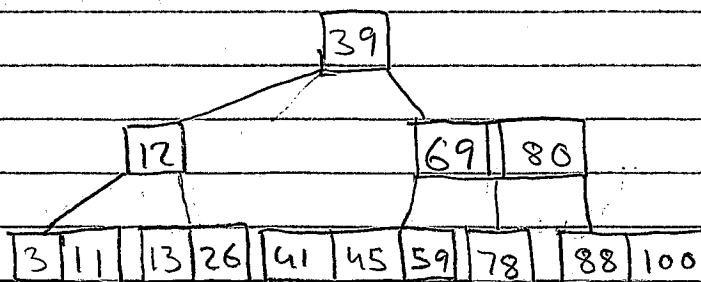
Search for 74:



remove 74, notice underflow:



demote parent into deleted location,
promote closest sibling:



③ Data from question:

N : 13,371,337 disk block: $1e9$ b

key: 4,000 b record size: $1e6$ b

pointer: 4,000 b

$$a) \text{ disk block} = (M_i - 1) \cdot \text{key} + M_i \cdot \text{pointer}, M_f = \lfloor M_i \rfloor$$

$$\rightarrow 1e9 \text{ b} = (M_i - 1) 4000 \text{ b} + 4000 \text{ b} M_i$$

$$\rightarrow 1e9 \text{ b} = 4000 M_i \text{ b} - 4000 \text{ b} + 4000 M_i \text{ b}$$

$$\rightarrow (1e9 + 4000) \text{ b} = 8e3 M_i \text{ b}$$

$$\rightarrow M_i = 125,000.5$$

$$\therefore M_f = \lfloor 125,000.5 \rfloor = 1.25e5$$

$$L = \left\lfloor \frac{\text{disk block}}{\text{record size}} \right\rfloor$$

$$\rightarrow L = \left\lfloor \frac{1e9 \text{ b}}{1e6 \text{ b}} \right\rfloor = 1,000$$

$$b) \text{ Max } M = N \cdot \text{record size} / \text{disk block} \\ = (13,371,337) (1e6 \text{ b}) / (1e9 \text{ b}) \\ \approx 13,371 \text{ (best case)}$$

$$\text{Max } \frac{M}{2} = 2 \times 13,371 \approx 26,742 \text{ (worst case)}$$

$$c) \text{ height} = \lceil \log_{\frac{M}{2}} N \rceil = \lceil \log_{62,500} 13,371,337 \rceil = 2, \because \text{root is in memory}$$

$$\therefore \text{height} = 1$$

$$= \lceil \log_M N \rceil = \lceil \log_{13,371} 13,371,337 \rceil = 2, \because \text{root is in memory}$$

$$\therefore \text{height} = 1 \text{ (best and worst case)}$$

d) The number of disk access is the height of the B-tree + the level the root is on, so $1+1=2$ \square

4) Minimum degree, t , of a B-tree is directly dependant on the number of keys or data that can be stored in any node, t or $t-1$. If $t=1$, then the number of data that can be held per node would be 1 or 0. The B-tree then loses its property \square

5) Insert the following into a hash table with $K=29$:

46, 91, 51, 26, 64, 89, 12, 98, 41, 31, 62, 36, 49, 39, 95, 75, 20, 38, 27, 11, 24, 43, 90, 22, 18, 21, 55, 28, 87

*Linear probing:

28	87	89	31	91	62	64	36	95	38	39	98	12	41	11	43	90	46
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
75	18	49	20	51	22	24	21	26	27	55							
18	19	20	21	22	23	24	25	26	27	28							

$$h(46) = 17$$

$$h(39) = 10$$

$$h(55) = 26 \rightarrow 27 \rightarrow 28$$

$$h(91) = 4$$

$$h(95) = 8$$

$$h(28) = 28 \rightarrow 0$$

$$h(51) = 22$$

$$h(75) = 17 \rightarrow 18$$

$$h(87) = \emptyset \rightarrow 1$$

$$h(26) = 26$$

$$h(20) = 20 \rightarrow 21$$

$$h(64) = 6$$

$$h(38) = 9$$

$$h(89) = 2$$

$$h(27) = 27$$

$$h(12) = 12$$

$$h(11) = 11 \rightarrow 12 \rightarrow 13 \rightarrow 14$$

$$h(98) = 11$$

$$h(24) = 24$$

$$h(41) = 12 \rightarrow 13$$

$$h(43) = 14 \rightarrow 15$$

$$h(31) = 2 \rightarrow 3$$

$$h(90) = 8 \rightarrow 9 \rightarrow 10 \rightarrow 11 \rightarrow 12 \rightarrow 13 \rightarrow 14 \rightarrow 15 \rightarrow 16$$

$$h(62) = 11 \rightarrow 5$$

$$h(22) = 22 \rightarrow 23$$

$$h(36) = 7$$

$$h(18) = 18 \rightarrow 19$$

$$h(49) = 20$$

$$h(21) = 21 \rightarrow 22 \rightarrow 23 \rightarrow 24 \rightarrow 25$$

Number of probes: 32

* Quadratic probing:

22 21 89 31 91 62 64 36 95 38 39 98 12 41 (55) 11 87 46 75 90
 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
 49 20 51 43 24 18 26 27 28
 20 21 22 23 24 25 26 27 28

overloaded bin

$$h(46) = 17$$

$$h(38) = 9$$

$$h(91) = 4$$

$$h(27) = 27$$

$$h(51) = 22$$

$$h(11) = 11 \rightarrow 12 \rightarrow 15$$

$$h(26) = 26$$

$$h(24) = 24$$

$$h(64) = 6$$

$$h(43) = 14 \rightarrow 15 \rightarrow 18 \rightarrow 23$$

$$h(89) = 2$$

$$h(90) = 3 \rightarrow 4 \rightarrow 7 \rightarrow 12 \rightarrow 19$$

$$h(12) = 12$$

$$h(22) = 22 \rightarrow 23 \rightarrow 26 \rightarrow 27 \rightarrow 29 \rightarrow 18 \rightarrow 10$$

$$h(98) = 11$$

$$h(18) = 18 \rightarrow 19 \rightarrow 22 \rightarrow 27 \rightarrow 8 \rightarrow 14 \rightarrow 25$$

$$h(41) = 12 \rightarrow 13$$

$$h(21) = 21 \rightarrow 22 \rightarrow 25 \rightarrow 13$$

$$h(31) = 2 \rightarrow 3$$

$$* h(55) = 26 \rightarrow 27 \rightarrow 10 \rightarrow 13 \rightarrow 22 \rightarrow 4 \rightarrow 10$$

$$h(62) = 4 \rightarrow 5$$

$$h(28) = 28$$

$$h(36) = 7$$

$$h(87) = 0 \rightarrow 1 \rightarrow 4 \rightarrow 9 \rightarrow 16$$

$$h(49) = 20$$

$$h(39) = 10$$

$$h(95) = 8$$

$$h(75) = 17 \rightarrow 18$$

$$h(20) = 20 \rightarrow 21$$

Number of probes: undetermined