Topic Huffman Coding Unit No. 01

- It was First developed by David Huffman in 1951
- It is data Compression technique in which size of data / message is reduced.
- Variable length Coding algorithm
- Reducing size of file / Message without losing any of the details

Huffman Coding

Suppose the string below is to be sent over a network.

B	C	A	A	D	D	D	C	C	A	C	A	C	A	C

Initial String

As we know that, Each character occupies 8 bits,
According to ASCII,

A = 65 = 01000001
B = 66 = 01000010
:
& so on,

As in given string total 15 strings so total 15 X 8 = 120 bits required to store / send data

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We can send the above data by using fixed length coding

Let us consider the following string

ABBCDBCCDAABBEEEBEAB

In the above string total 20 characters

Each character required 8 bits to store (ASCII)

∴ Total Bits required = 20 × 8 = 160 bits

Now another method, fixed length coding

2 bits can represent 4 characters

ex. 00, 01, 10, 11 } 2 bits

& 3 bits can represent 8 characters

000, 001, ..., 111 } 4 bits

& so, on.

as in the given string only 5 different character i.e. A, B, C, D, E so we required 3 bits (8 combination)

Table:1

000	A
001	B
010	C
011	D
100	E
101 }	unused
110 }	
111 }	

∴ The string. ABBCDBCC DAABBEEEBE
AB

000 001 001 010 011 ---- & so on

So here for each character 3 bits required

Total no. of bits = 20X3 = 60 bits

Now for Decoding the message which is sent on the network, need required Table 1

so for sending the Table required 5 character (5X8 = 40 bits) & 3 bits for each character (3X5 = 15 bits)

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∴ Total Number of bits Required for this method

Table 1 info

$= 20 \times 3 + 5 \times 8 + 5 \times 3$

(3 bits for each character) (5 different char A, B, C, D, E 8 bits each) + (3 bits for each char. Total 5 char)

Now Consider Variable length Coding

Huffman Coding

Here length of bits is not fixed for each character it is different

Now Consider the string

A B B C D B C C D A A B B E E E B E A B

Step 1 Write the frequency of each (count) character.

∴

char	Frequency / Count of Each char
A	4
B	7
C	3
D	2
E	4

Step 2

Now Design Huffman Tree.

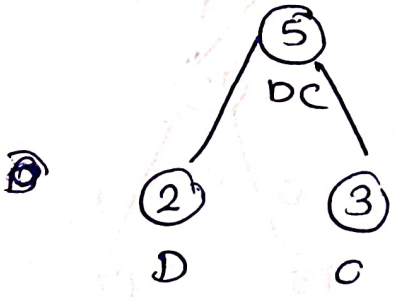
So here arrange all character in increasing order according to their frequency count

∴

~~char~~	D	C	E	A	B
	2	3	4	4	7

Step 3 Select Two least Frequency Count character. (Left side of Tree .. Lowest count value)

D	C	E	A	B
2	3	4	4	7



Now, arrange the count again

E	A	DC	B
4	4	5	7

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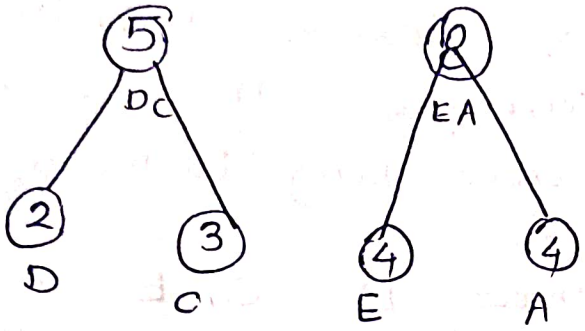
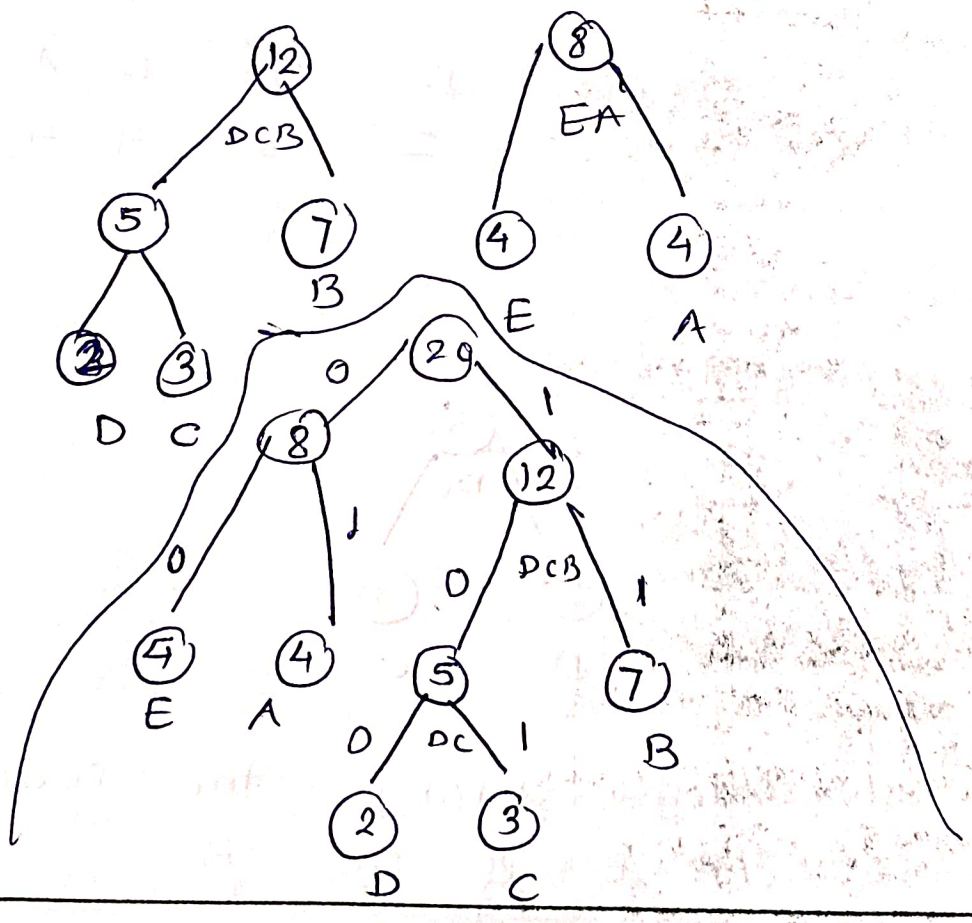


Now, Again Arrange the character Acc. to new frequency count

5 7 8
DC B EA



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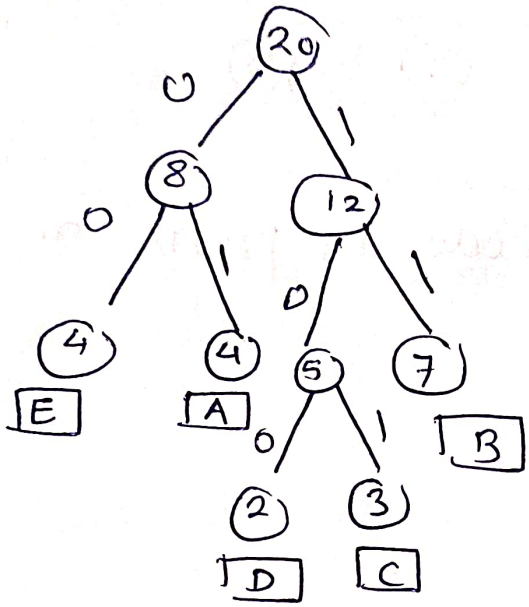


Now find the huffman coding for each node

Char	Huffman code	Frequency count	Total Bit for Each character = Freq count * Total Bit
A	= 01	4	4X2 = 8
B	= 11	7	7X2 = 14
C	= 101	3	3X3 = 9
D	= 100	2	2X3 = 6
E	= 00	4	4X2 = 8
		Total	= 45 bits

Also Table need to send & for Table required Total Bits.

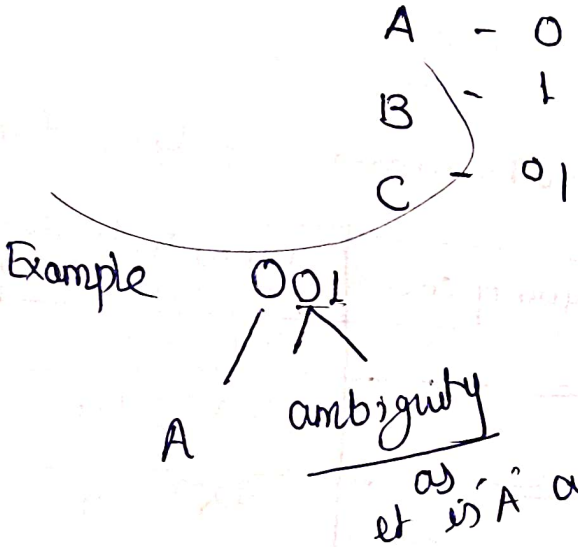
= 5(char) X 8 bit(Each char)
+ Total Bits 12 bits (All char)
= 40+12 = 52

Total Number of Bits = 52 + 45
= 97 bits

Time Complexity O(n log n)

Prefix Code: NO code is prefix of another Code.

for Example



001 ⇒ AAB

OR 001 ⇒ AC

- Encoding follows the prefix rule
- most generated char will get the small code & least generated char will get the large code.
- Time Complexity O(n log n)

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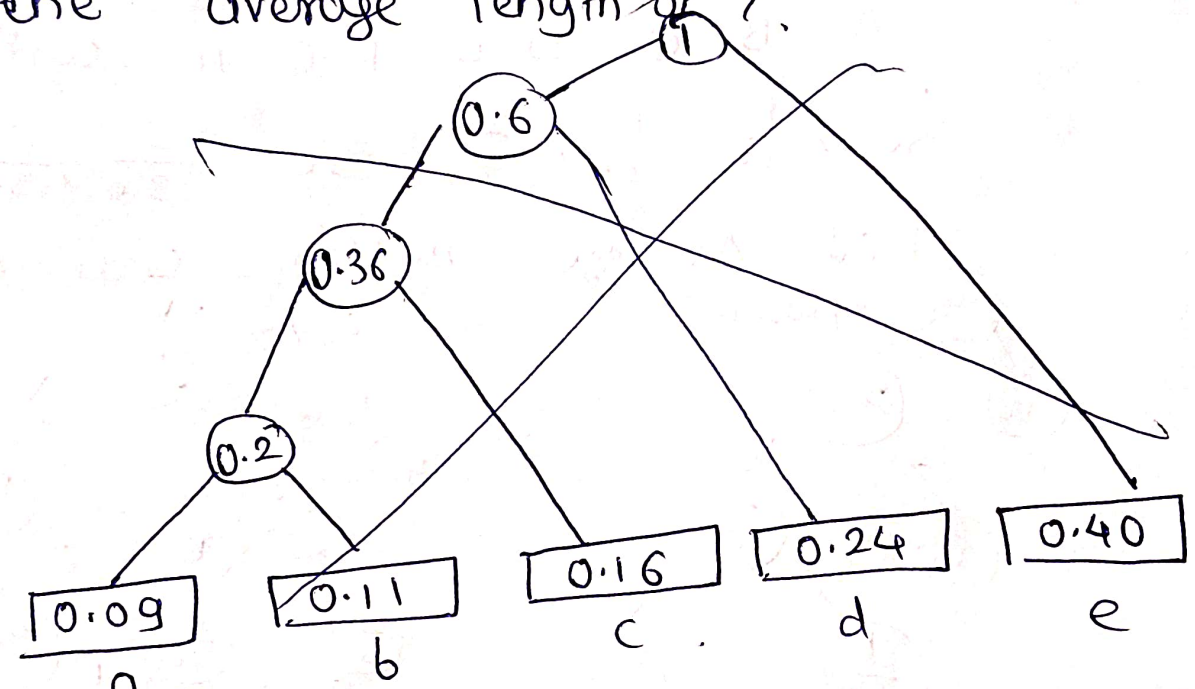
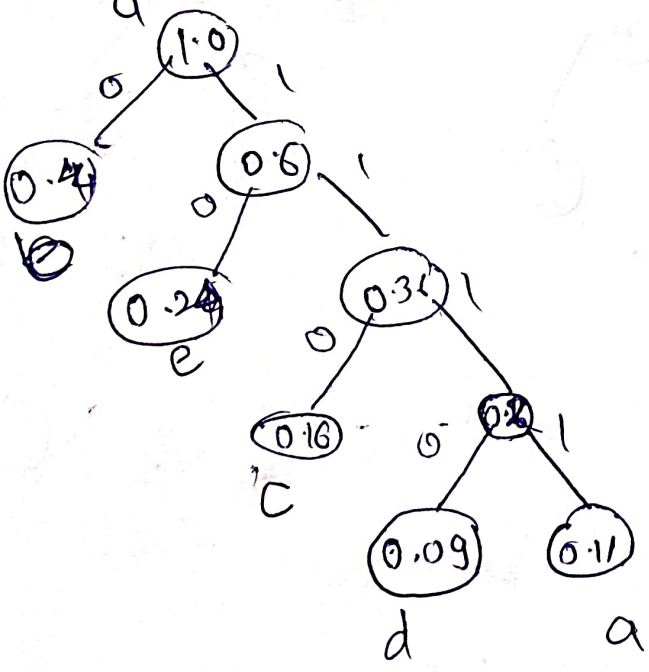
A Text is made up of the characters a, b, c, d, e each occuring with the probability 0.11, 0.40, 0.16, 0.09 & 0.24 resp. The optimal Huffman coding tech will have the average length of ?.





char	Probabilities	Huffman code
a	0.11	1111 = 4
b	0.40	0 = 1
c	0.16	110 = 3
d	0.09	1110 = 4
e	0.24	10 = 2

Total Bits = char * problem $= \sum_{i=1}^{n} (Pp * bi)$

Total Bits

Total Bits = $a \times 4 + b \times 1 + c \times 3 + d \times 4 + e \times 2$

$= 0.11 \times 4 + 0.40 \times 1 + 0.16 \times 3 + 0.09 \times 4 + 0.24 \times 2$

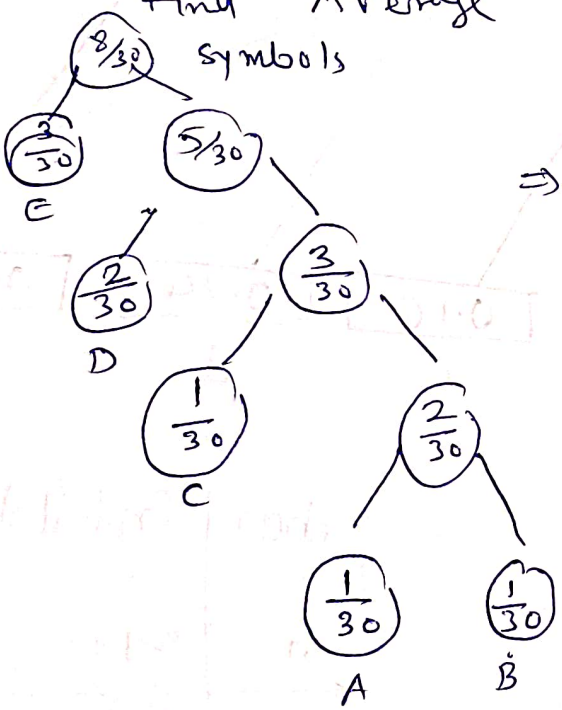
$= 0.44 + 0.40 + 0.48 + 0.36 + 0.48$

$= 2.16$ bits / symbol

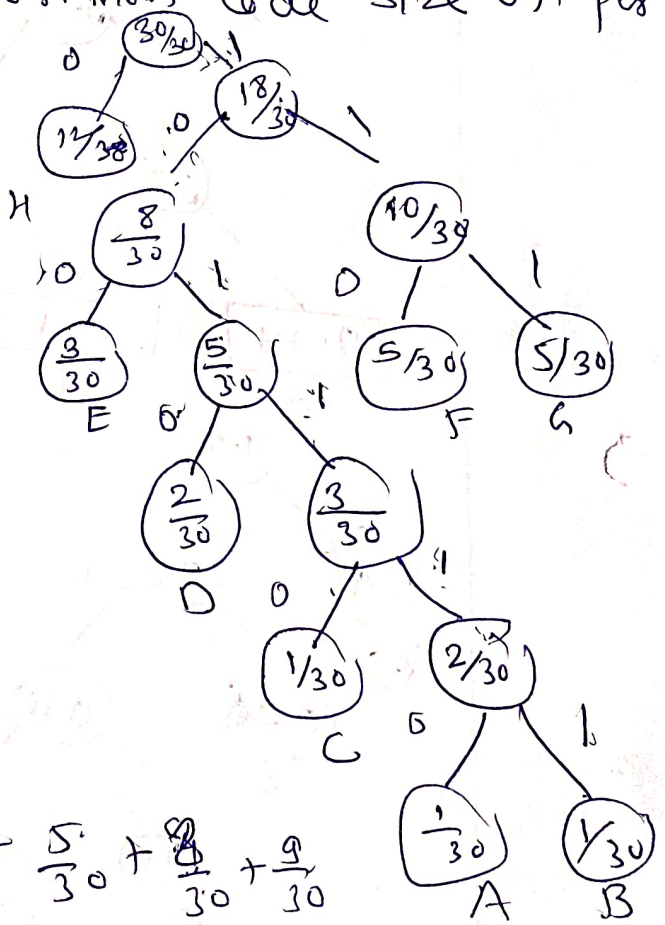
Ex ③

A B C D E F G H with probab $\frac{1}{30}, \frac{1}{30}, \frac{1}{30}, \frac{2}{30}, \frac{3}{30}, \frac{5}{30}, \frac{5}{30}, \frac{12}{30}$ resp.

Find Average Huffman code size bit per symbols



⇒



A

B

C H = 0

D

E

F

G

H 0

$\frac{6}{30} + \frac{6}{30} + \frac{5}{30} + \frac{8}{30} + \frac{9}{30} + \frac{15}{30} + \frac{15}{30} + \frac{12}{30}$

$= \frac{76}{30}$ bits / symbol

(1)