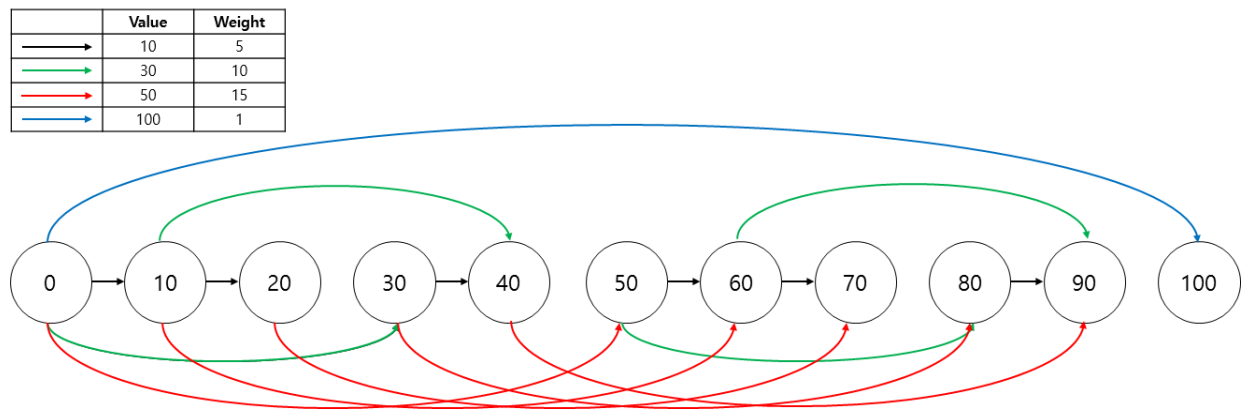


1.

(a)



(b)

① Make an array $U[c]$, which has the value of $\frac{W[c]}{V[c]}$. This means the cost of weight per a value.

② Let $x_1 = x_0 - V[c]$, such that the smallest value $U[c]$ in the array U which satisfies $V[c] < x$, and $x_0 = x$. Let this value c as c_1 .

③ Go to the next node $V[c_1]$. If there is no edge, call $createEdge(0, V[c_1], W[c_1])$. Let's call this node n_1 .

④ If $x_1 = 0$, it terminates. If not, go to the step 2, do those again until x_i becomes zero. For example, after $i-1$ iteration, if x_{i-1} is not zero, go to the step 2. In step 2, we can get x_i such that $x_i = x_{i-1} - V[c_{i-1}]$ which satisfies step 2 conditions. After that, go to the step 3. If $x_i \neq 0$, call $createEdge(n_{i-1}, n_{i-1} + V[c_{i-1}], W[c_{i-1}])$. This will create path with smallest weight from 0 to x .

(c)

Under the condition that all $W[c]$ are positive, the graph is always a DAG. Currencies cannot have negative value so $V[c]$ can't be negative. Since edges in the graph always go toward nondecreasing direction, there can't be a edge which goes backward(decreasing direction) and form this, there can't be a cycle.

2.

(a) /0/1/00/01/011/, 15times.

(b) Bob is true.

I used given example.

relative frequency of character : $f_A \sim f_F$

and the number of transition is in below.

Character	# of transition($t_A \sim t_F$)
A	1
B	2
C	2
D	3
E	3
F	4

So, running time can be represented by

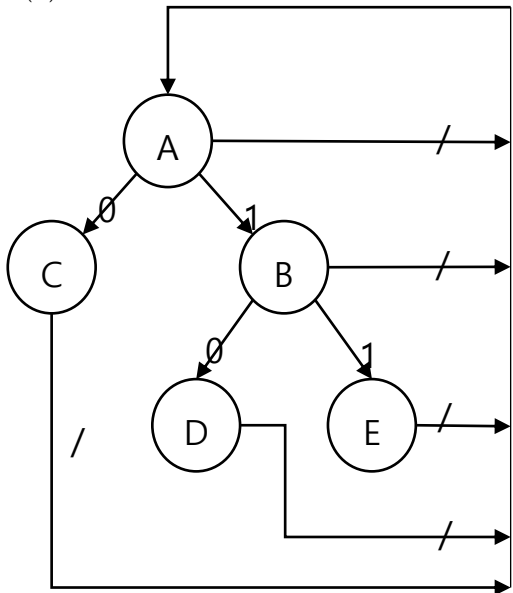
$$f_A t_A + f_B t_B + f_C t_C + f_D t_D + f_E t_E + f_F t_F = f_A + 2f_B + 2f_C + 3f_D + 3f_E + 4f_F$$

Let's think about the point of $f_A = 0.5$ and $f_B + f_C + f_D + f_E + f_F = 0.5$.

The f_A grows bigger, the whole running time becomes smaller. The number of descendent's transition is always bigger than that of the parent. So coefficient of f_A is smaller than the sum of the other coefficients, and sum of frequencies equal to 1, constantly. These characteristics hold in the subset of descendent(subtree).

Therefore, the larger ascendent's frequency is, the smaller whole running time will be.

(c)



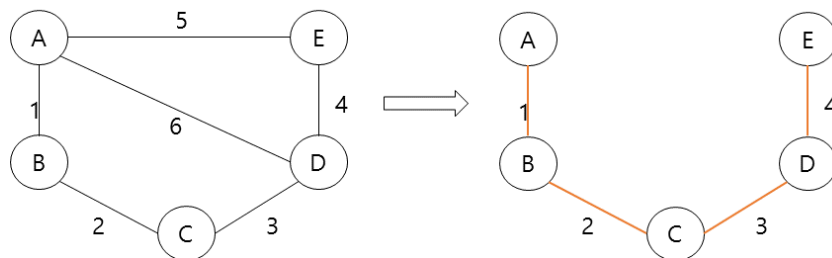
3. Morse Code is not a prefix-free code.

SOS HELP → 000 111 000 0000 0 0100 0110 → 0001110000000001000110

I AM HIS DATE → 00 01 11 0000 00 000 100 01 1 0 → 0001110000000001000110

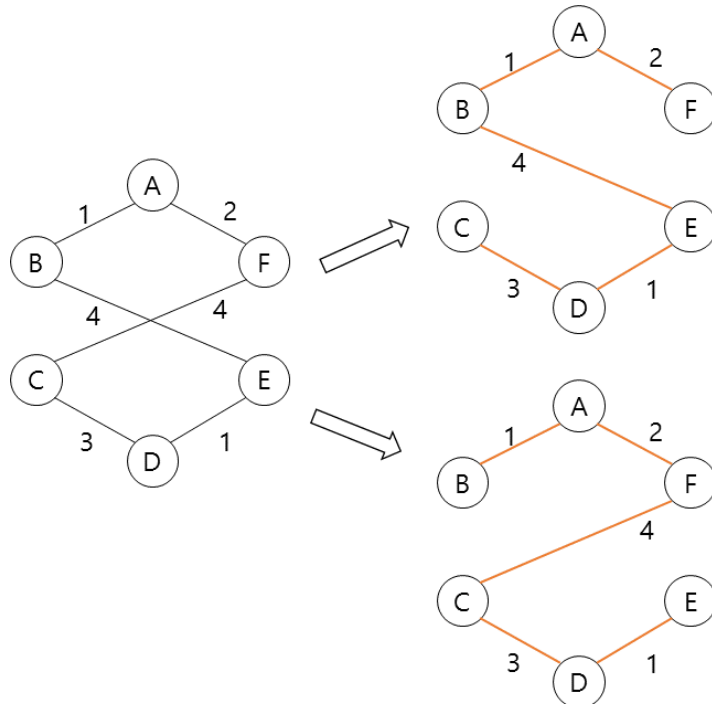
4.

(a)



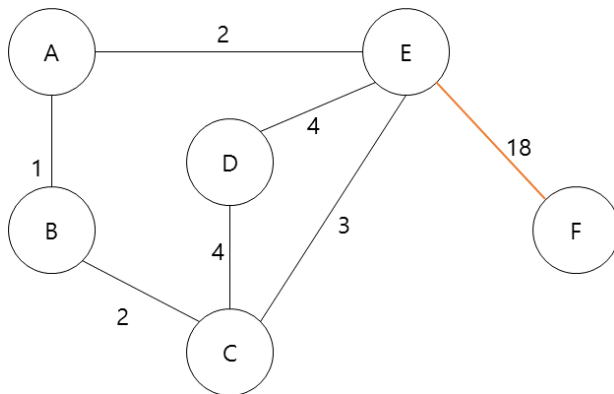
① Unique MST

② Exactly two MST



(b)

Edge EF has maximum weight. It must be included in MST in order to contain node F.



(c) All edges in the graph have same weight.

