(While expanding any node, to break tie, you have to consider the nodes in lexicographical order that is expand A before B, B before C, AX before BZ etc)

1. **Suppose you are searching words only made by the letters B, D, I and R. So you write down the possible words as follows: B, D, I, R, BB, BD, BI, BR, DB, …**

    a. **(Mark 2+3) Are you doing Breadth First Search or Depth First Search (storing nodes to avoid revisit)? Write down first five terms of "the other" searching method.**

    b. **(Mark 5) How many nodes will be visited before getting BIRD in BFS and DFS (storing a node to avoid revisit)? [Show the sequence or show your calculation or draw the tree]**

    c. **(Bonus 2) What about finding word BIRDBIRDBIRD in BFS and DFS?**

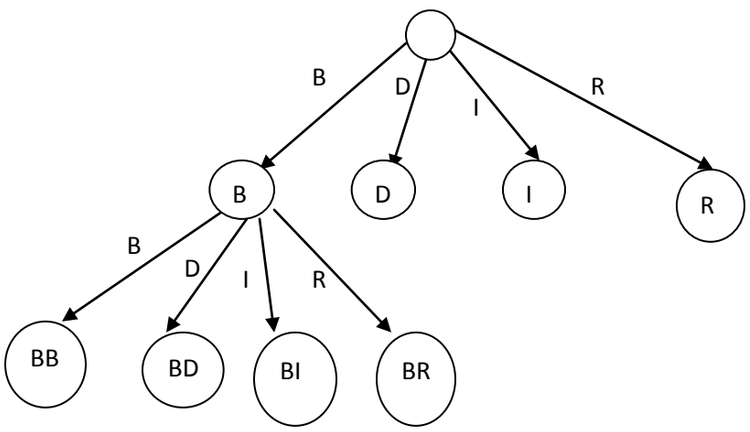
Solution:

1 a:

We are doing BFS here. First five terms of DFS: B, BB, BBB, BBBB, BBBBB

The reason of this problem is to find if one understands BFS and DFS. And This 5 mark is very easy 5 marks.

If we extend the terms then we will see that, first only one character term appears, then 2 character terms, then 3 … If it was DFS then at each term the length would have increased. The big hint for BFS is, chunk by chunk length increase. Now if you want to imagine the tree keep the 1 lengths at 1 depth, 2 lengths at 2 depth … So the tree will become like:



However, Some students considered DFS nodes while expanding a node, in such case sequence will be B, D, I, R, BB, BD, BI, BR, BBB, BBD … They are also given marks, but some students wrote B, D, I, R, BB which is part of BFS and DFS too. In such case marks is given on the basis of the searching tree drawn or benefit of doubt.

1 b:

As was told, it is sufficient to just write down all the words, or the tree or just number.

If you write down the words then: B, D, I, R, BB, BD, BI, BR, DB, DD, DI, DR, … BIRD. Now count. But obviously this is going to be very tedious way. If you draw the tree then it will be also big messy as the branching factor is 4. But if you notice while drawing the tree and remember our time and space complexity analysis of BFS then it will be easy to answer.

In the 0th level just the empty string, so 1 node.

In 1st level just 1 length words B, D, I and R. So 4 nodes.
In 2nd level just 2 length words, so, 4*4 = 16 nodes.
In 3rd level just 3 length words, so 4*4*4 = 64 nodes.
In the 4th level there is the answer. Now the question is how many words before BIRD?

Words of form BB?? = 4*4
Words of form BD?? = 4*4
Words of form BIB? = 4, BID? = 4, BIRB = 1, BIRD (the soln)

So how many words in total? Just add up the numbers ☺

For DFS, as we have seen in 1a, it will go like B, BB, BBB … and never finds BIRD.

The reason of this question is, if the student can notice that the knowledge of time/space analysis comes in play here. However, many of the students counted number of expanded node instead of visited node. It is not a big issue in this problem. All the students who noticed this time/space complexity matter are given full marks. But, some students just wrote O(4^4) or 4+16+..+4^4. These students are given partial marks (2, 3 or 4 depending on the answer of DFS).

1 c:

If we continue in the above fashion obviously the way to find the count for BIRDBIRDBIRD may be very tedious. Some noticed the relation between the character and the coefficient of 4^i.

Lets notice the 3 character words: BBB, BBD, BBI, BBR, BDB, BDD, BDI, BDR, BIB, BID, BII, BIR … What does it look like? The pattern will be more clear if you convert B->0, D->1, I->2 and R->3. Then, 000, 001, 002, 003, 010, 011, 012, 013, 020, 021 … It is 4 base number. So if you convert this 4 base number to 10 base number you will get the number of words appeared before the given word in the last lever. And above this level number of words are: 4 + 4^2 + … + 4^(level-1).

For example: BIRD -> 0231 = 0*4^3 + 2*4^2 + 3*4^1 + 1*4^0 = ?
Same for BIRDBIRDBIRD.

To get marks it was sufficient to just write down this form. However, there was no partial marks for bonus.

2. **Suppose you are playing a game. Initially you start with empty word. Then at each turn you may add or remove any character at/from any position in the word. But the resulting word should be within the set: A, AT, AN, RT, TR, RAT, ART, PAT, ANT, PRT, PART, PANT, ANTS.**

    a. **(Mark 4) Can you design a graph model for this problem? (Just draw the graph. Help: There will be 17 edges in the graph)**

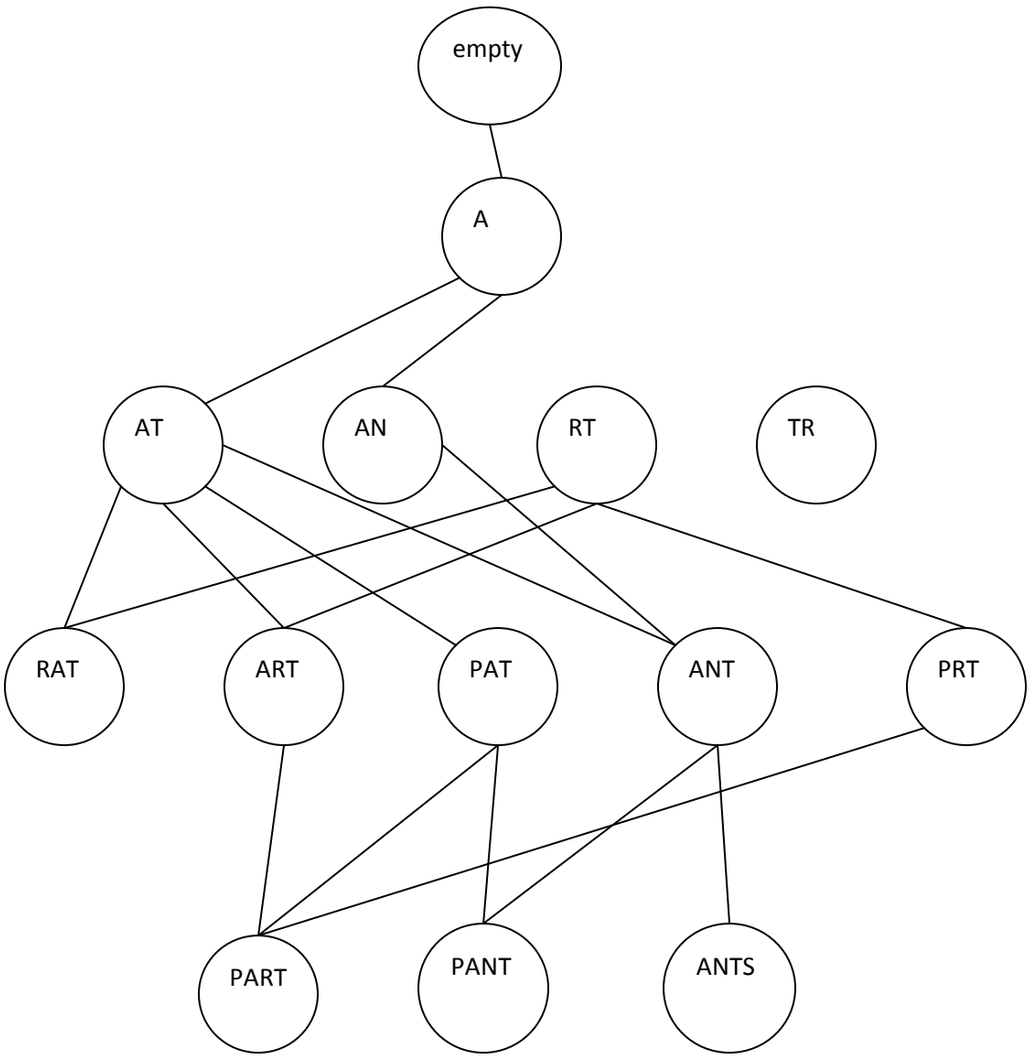
    b. **(Mark 6) Starting with empty string search for the word ANTS by Iterative Deepening DFS.**

Soltuion:

2 a:

As it was asked to draw graph the first question should arise what is node and what is edge? Some tried to relate it to DFA/NFA if you remember from Theory of Computation course. They are given 4 if correct and 3 if they did not handle TR node properly. Some tried to draw a tree but if you draw tree then you cant relate AT and PT. Or say PRT and PART where insertion was made in middle. They are also given partial mark 2. So it is obvious that tree representation is not possible.

However, it is clear that all the words are state. And action is add/delete operation. As we have seen in class state is node and action is edge. So the graph is: All the words are node (include empty string too) and there will be edge between two nodes if one word can be obtained from the other word by insertion/deletion of a character at any place. So the graph is: (Well, if you are clever enough, you will put d length word at d depth, it will make your drawing easy ☺)



Some added extra node T to relate TR, and some did not draw the node TR, they are given 3.

If you have drawn the nodes in a level in lexicographical order then it will become easier to draw the tree for ID-DFS. For ID-DFS your root will be empty string and will finish when you are at ANTS. However, those who even did ID-DFS in wrong graph are also given partial marks up to 4. But I am afraid, it won't be possible to give partial marks in final exam in such circumstance.