

Lab 3: Twenty Questions
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1. This data cannot be stored as a binary search tree because a BST has the property that for any given node, all nodes in the left subtree must be less than that node, and all nodes in the right subtree must be greater. “Less than” and “greater than” can have whatever definition is applicable for a given situation, but here it is not clear how these terms are defined. Perhaps the average weight of a given animal could be used to determine size for comparison. However, animals are only represented by leaf nodes; all non-leaf nodes in this tree are questions. Possibly a rule for size could be the length of the string held in the node’s data. However, since the tree depends on user input, there is no way to force the binary tree to be a BST. Looking at the example tree used in the test specification, it can be seen that “Cat” is the right child of “Does it have long legs?” If we are using string length to judge size, this is a clear violation. For these reasons, this data cannot be stored as a BST.
2. The table below shows the maximum number of animals vs. number of questions. This was obtained by assuming that any given path through the tree will reach the maximum number of questions before reaching a leaf node.

Number of Questions	Maximum number of Animals
0	1
1	2
2	4
3	8
4	16
...	...
20	1048576

An exponential relationship becomes clear as $N_{\text{Animal}} = 2^{N_{\text{Questions}}}$. So, the maximum number of animals in the database is 1048576 if only twenty questions are allowed.

3. While training the program, the user could provide answers such that each question has at most only 1 leaf node (aside from the last non-leaf node). In fact, this is what was done in the test program, though we only provided 3 questions. In this scenario, we can quickly build a path of questions longer than 20. By minimizing subtrees, we can easily create a guessing session where the computer cannot guess within twenty questions.