Trie | (Insert and Search)

What is Trie?

> Trie is a type of k-ary search tree used for storing and searching a specific key from a set. Using Trie, search complexities can be brought to optimal limit (key length).

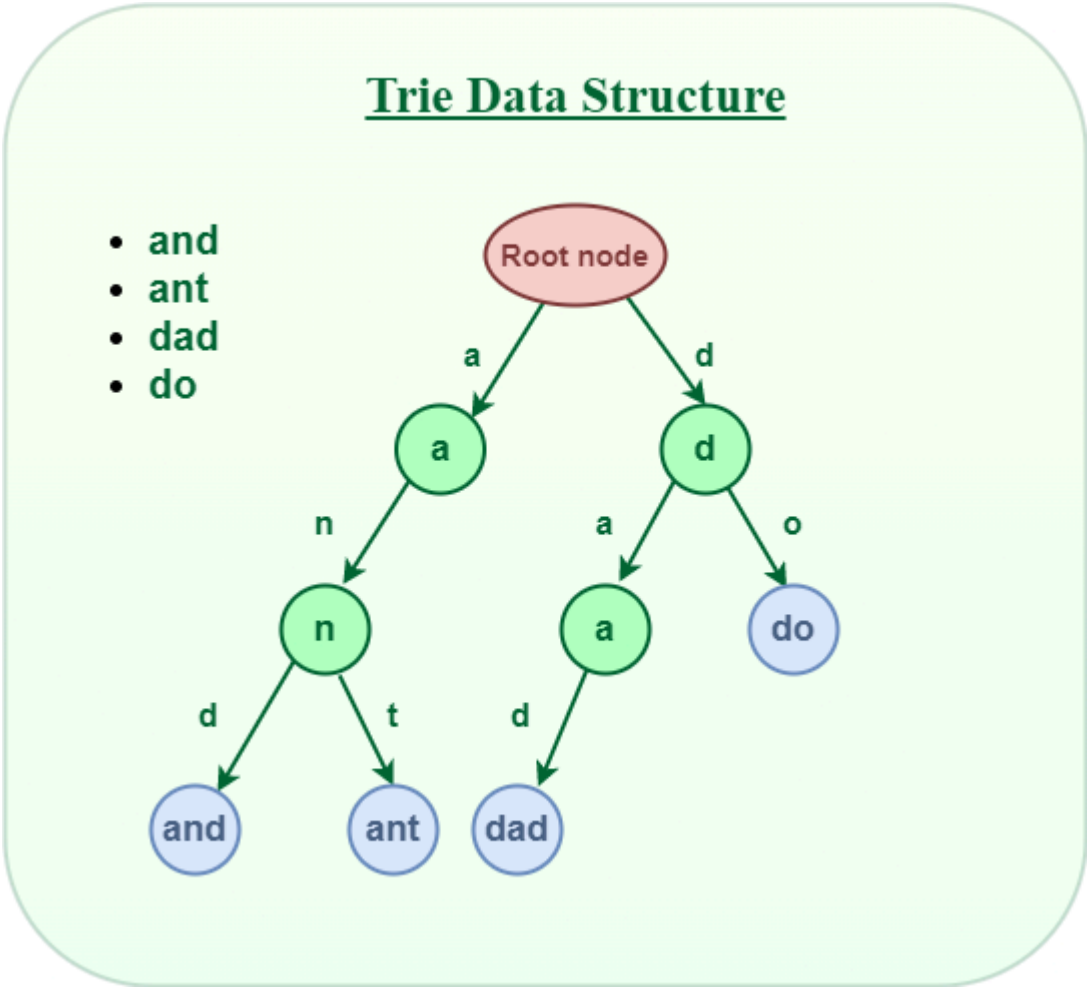
Definition: A trie (derived from retrieval) is a multiway tree data structure used for storing strings over an alphabet. It is used to store a large amount of strings. The pattern matching can be done efficiently using tries.

The trie shows words like allot, alone, ant, and, are, bat, bad. The idea is that all strings sharing common prefix should come from a common node. The tries are used in spell checking programs.

- Preprocessing pattern improves the performance of pattern matching algorithm. But if a text is very large then it is better to preprocess text instead of pattern for efficient search.
- A trie is a data structure that supports pattern matching queries in time proportional to the pattern size.

If we store keys in a binary search tree, a well balanced BST will need time proportional to **M * log N**, where **M** is the maximum string length and **N** is the number of keys in the tree. Using Trie, the key can be searched in **O(M)** time. However, the penalty is on Trie storage requirements (Please refer to Applications of Trie for more details).

Trie is also known as **digital tree** or **prefix tree**. Refer to **this** article for more detailed information.



Trie data structure

Structure of Trie node:

Every node of Trie consists of multiple branches. Each branch represents a possible character of keys. Mark the last node of every key as the end of the word node. A Trie node field **isEndOfWord** is used to distinguish the node as the end of the word node.

A simple structure to represent nodes of the English alphabet can be as follows.

C++ Java

```java
// Trie node
class TrieNode
{
    TrieNode[] children = new TrieNode[ALPHABET_SIZE];
    // isEndOfWord is true if the node
    // represents end of a word
    boolean isEndOfWord;
}
```

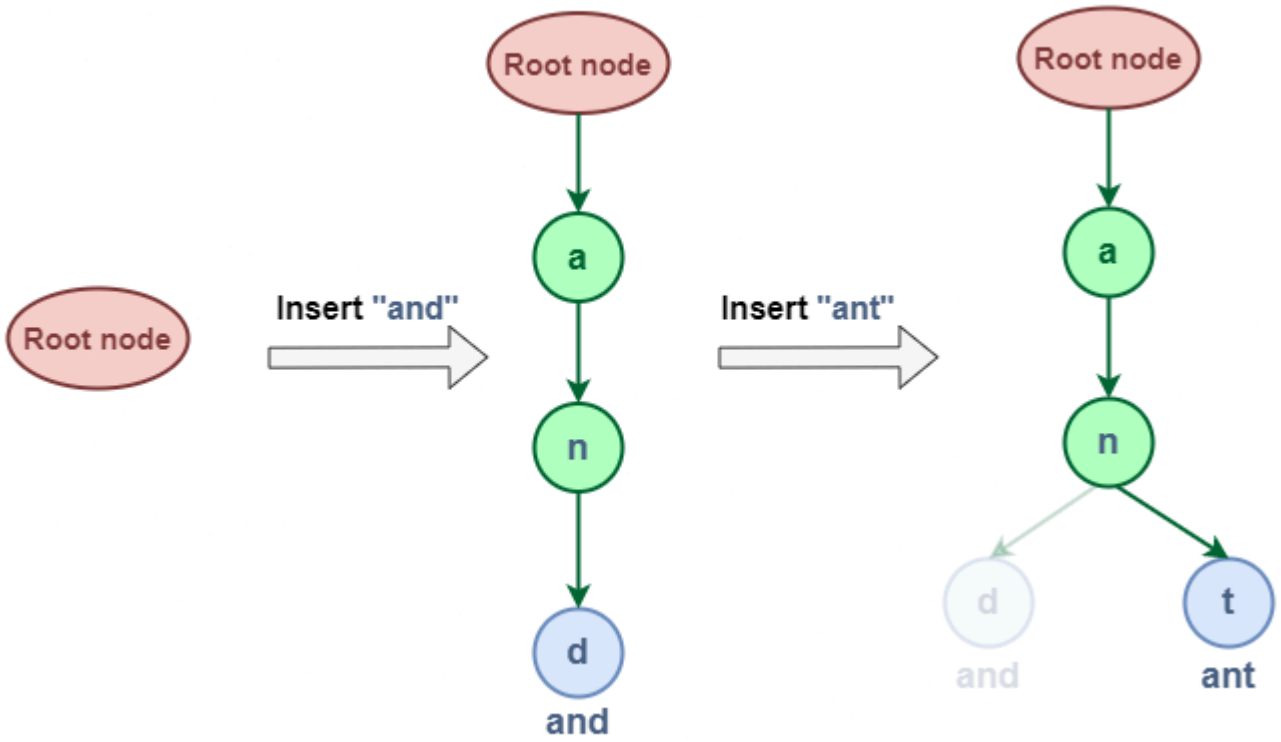
Insert Operation in Trie:

Inserting a key into Trie is a simple approach.

- Every character of the input key is inserted as an individual Trie node. Note that the **children** is an array of pointers (or references) to next-level trie nodes.
- The key character acts as an index to the array **children**.
- If the input key is new or an extension of the existing key, construct non-existing nodes of the key, and mark the end of the word for the last node.
- If the input key is a prefix of the existing key in Trie, Simply mark the last node of the key as the end of a word.

The key length determines Trie depth.

The following picture explains the construction of trie using keys given in the example below.



Insertion operation

Advantages of tries

1. In tries the keys are searched using common prefixes. Hence it is faster. The lookup of keys depends upon the height in case of binary search tree.

2. Tries take less space when they contain a large number of short strings. As nodes are shared between the keys.

3. Tries help with longest prefix matching, when we want to find the key.

Comparison of tries with hash table

1. Looking up data in a trie is faster in worst case as compared to imperfect hash table.

2. There are no collisions of different keys in a trie.

3. In trie if single key is associated with more than one value then it resembles buckets in hash table.

4. There is no hash function in trie.

5. Sometimes data retrieval from tries is very much slower than hashing.

6. Representation of keys a string is complex. For example, representing floating point numbers using strings is really complicated in tries.

7. Tries always take more space than hash tables.

8. Tries are not available in programming tool it. Hence implementation of tries has to be done from scratch.

Applications of tries

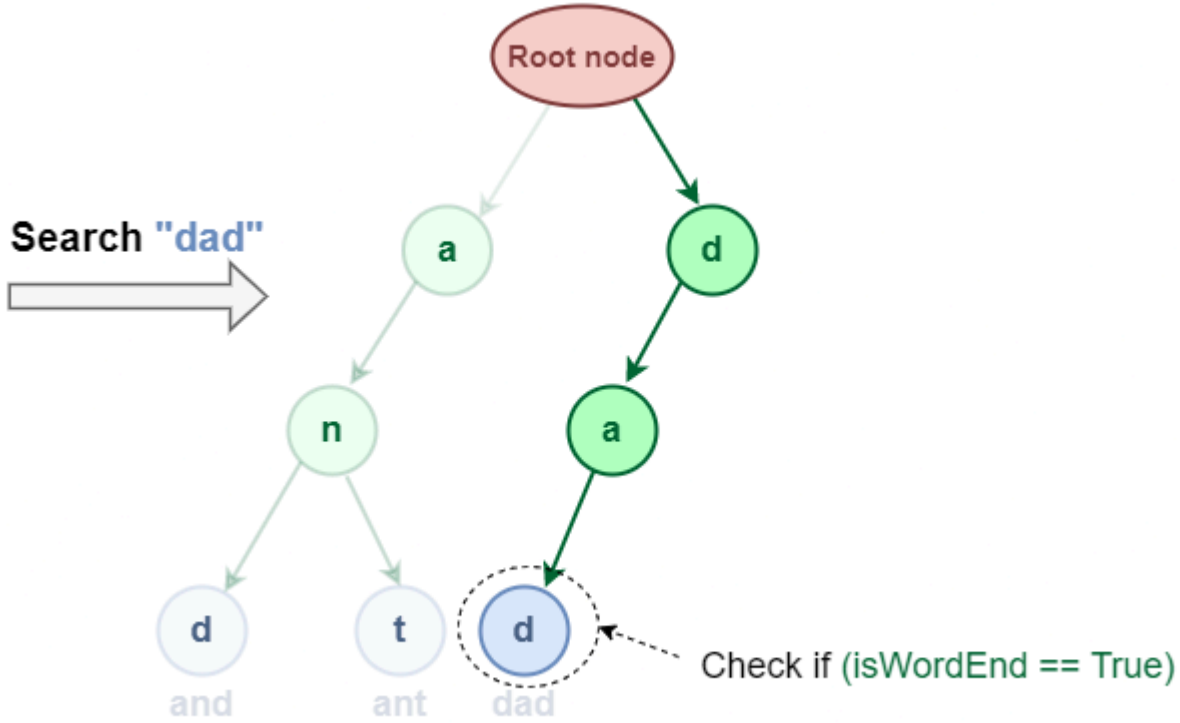
1. Tries has an ability to insert, delete or search for the entries. Hence they are used in building dictionaries such as entries for telephone numbers, English words.

2. Tries are also used in spell-checking softwares.

Search Operation in Trie:

Searching for a key is similar to the insert operation. However, It only **compares the characters and moves down**. The search can terminate due to the end of a string or lack of key in the trie.

- In the former case, if the **isEndofWord** field of the last node is true, then the key exists in the trie.
- In the second case, the search terminates without examining all the characters of the key, since the key is not present in the trie.



Searching in Trie

Note: Insert and search costs **O(key_length)**, however, the memory requirements of Trie is **O(ALPHABET_SIZE * key_length * N)** where N is the number of keys in Trie. There are efficient representations of trie nodes (e.g. compressed trie, ternary search tree, etc.) to minimize the memory requirements of the trie.

How to implement a Trie Data Structure?

- Create a root node with the help of **TrieNode()** constructor.
- Store a collection of strings that have to be inserted in the trie in a vector of strings say, **arr**.
- Inserting all strings in Trie with the help of the **insert()** function,
- Search strings with the help of **search()** function.

Below is the implementation of the above approach:

C++ Java

```java
// Java implementation of search and insert operations
// on Trie
public class Trie {

    // Alphabet size (# of symbols)
    static final int ALPHABET_SIZE = 26;

    // trie node
    static class TrieNode
    {
        TrieNode[] children = new TrieNode[ALPHABET_SIZE];

        // isEndOfWord is true if the node represents
        // end of a word
        boolean isEndOfWord;

        TrieNode(){
            isEndOfWord = false;
            for (int i = 0; i < ALPHABET_SIZE; i++)
                children[i] = null;
        }
    };

    static TrieNode root;

    // If not present, inserts key into trie
    // If the key is prefix of trie node,
    // just marks leaf node
    static void insert(String key)
    {
        int level;
        int length = key.length();
        int index;
```

```
        TrieNode pCrawl = root;

        for (level = 0; level < length; level++)
        {
            index = key.charAt(level) - 'a';
            if (pCrawl.children[index] == null)
                pCrawl.children[index] = new TrieNode();

            pCrawl = pCrawl.children[index];
        }

        // mark last node as leaf
        pCrawl.isEndOfWord = true;
    }

    // Returns true if key presents in trie, else false
    static boolean search(String key)
    {
        int level;
        int length = key.length();
        int index;
        TrieNode pCrawl = root;

        for (level = 0; level < length; level++)
        {
            index = key.charAt(level) - 'a';

            if (pCrawl.children[index] == null)
                return false;

            pCrawl = pCrawl.children[index];
        }

        return (pCrawl.isEndOfWord);
    }

    // Driver
    public static void main(String args[])
    {
        // Input keys (use only 'a' through 'z' and lower case)
        String keys[] = {"the", "a", "there", "answer", "any",
```

```
                                "by", "bye", "their"};

        String output[] = {"Not present in trie", "Present in trie"};
```



```
        // Construct trie
        int i;
        for (i = 0; i < keys.length ; i++)
            insert(keys[i]);

        // Search for different keys
        if(search("the") == true)
            System.out.println("the --- " + output[1]);
        else System.out.println("the --- " + output[0]);

        if(search("these") == true)
            System.out.println("these --- " + output[1]);
        else System.out.println("these --- " + output[0]);

        if(search("their") == true)
            System.out.println("their --- " + output[1]);
        else System.out.println("their --- " + output[0]);

        if(search("thaw") == true)
            System.out.println("thaw --- " + output[1]);
        else System.out.println("thaw --- " + output[0]);

    }
}
// This code is contributed by Sumit Ghosh
```

Output

```
the --- Present in trie
these --- Not present in trie
their --- Present in trie
thaw --- Not present in trie
```


Complexity Analysis of Trie Data Structure:

Operation	Time Complexity	Auxiliary Space
Insertion	O(n)	O(n*m)
Searching	O(n)	O(1)