2. Trie Data Structure Notes

LinkedIn: Md. Ziaul Karim

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Topics: #tries #datastructures #tree

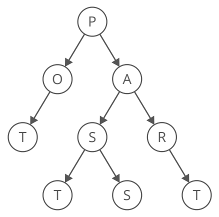
Introduction

A Trie is a tree-like data structure optimized for storing and searching strings or sequences of characters. It's excellent for prefix matching, autocomplete, and efficient word lookups. Tries are commonly used in search engines, spell-checkers, and any application involving text processing. They represent characters hierarchically, making them ideal for finding words with common prefixes.

Let's learn how Trie Data Structures work.

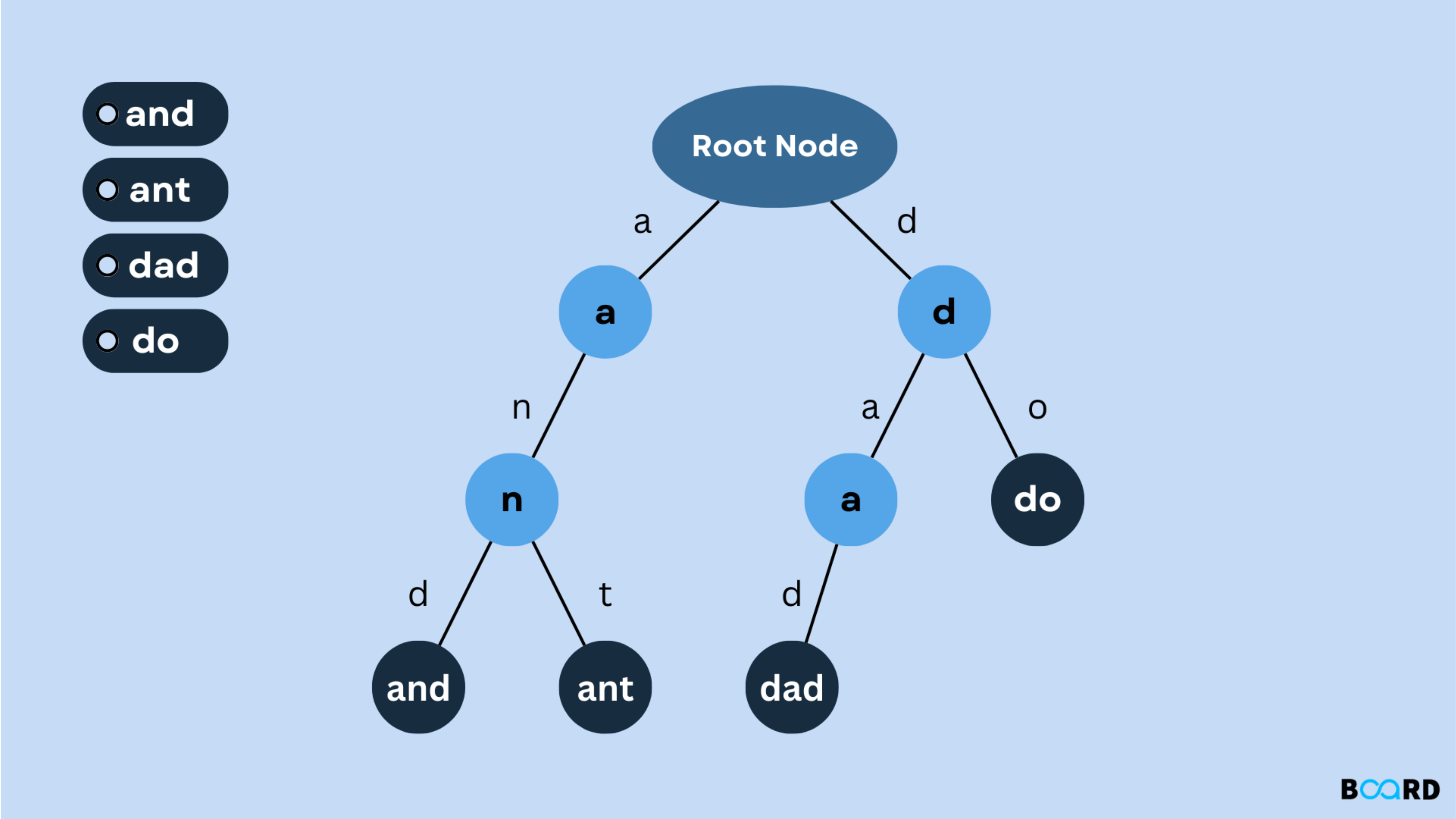
How words are stored in Trie

Example 1:



As we can see how the words "Pot" , "Past", "Pass", and "Part" are stored in a single Tree.

Example 2:



Characteristics of Trie DS

It's a tree like data structure, that stores data in a way that -
1. Words can be inserted character by character
2. Words can be inserted under same prefix
3. Search words easily (Similarity Suggestions etc.)
4. Prefix can be searched and identified as words.
5. Every node has two pointers - children -> str and isWord -> bool

Basically it's an efficient way to store data, because it can save us a lot of space.

Problems

Problem 1: Leetcode - Implement Trie Prefix Tree

Medium

```
class TrieNode:
        def __init__(self):
                self.children = {}
                self.endOfWord = False
class Trie:
        def __init__(self):
                self.root = TrieNode() #The root is an instance of the TrieNode() class
        #insert
        def insert(self, word:str) -> None:
                #starting from the root
                current = self.root #current is set to the root instance
                #for every character in the given word
                for c in word:
                        #check if that character exists in the children
                        if c not in current.children: # character doesn't exist
                                current.children[c] = TrieNode() #add that character to node
                        #character exists
                        current = current.children[c] # skip it and move to the next child
                #after all of them are added, mark the end of the word as True
                current.endOfWord = True

        #search
        def search(self, word:str) -> bool:
                # starting from the root
                current = self.root #current is set to the root instance
                # going through every character of the word
                for c in word:
                        # check if character exists in the children
                        if c not in current.children:
                                return False # the character doesn't exist
                        #character exists
                        current = current.children[c]  # skip it and move to the next child
                # if it reaches here word exists and that means it's True anyway.
                return current.endOfWord

        def startsWith(self, prefix: str) -> bool:
                #start from the root
                current = self.root
                #for every character in the prefix
                for c in prefix:
                        #if character is in children or not
                        if c not in current.children:
                                return False # not a prefix
                        #move to the next child
                        current = current.children[c]
                #if that for loop ends without returning that means we've checked all the characters
                return True

# Your Trie object will be instantiated and called as such:

obj=Trie()
param1 = ["Trie","insert","search","search","startsWith","insert","search"]
param2 = [[],["apple"],["apple"],["app"],["app"],["app"],["app"]]
output = []
operations={
    "Trie":None,
    "insert": obj.insert,
    "search": obj.search,
    "startsWith": obj.startsWith
}
for i in range(len(param1)):
    method = operations[param1[i]]
    if method is not None:
        output.append(method(param2[i][0]))
    else:
        output.append(None)
print(output)
```

Explanation

```
Operation 1: "Trie" Word: None
Tree: {}
return None
output: [None]

Operation 2: "insert" Word: "apple"
Tree: {
    "root": {
        "children": {
            "a": {
                "children": {
                    "p": {
                        "children": {
                            "p": {
                                "children": {
                                    "l": {
                                        "children": {
                                            "e": {
                                                "children": {},
                                                "endOfWord": true
                                            }
                                        },
                                        "endOfWord": false
                                    }
                                },
                                "endOfWord": false
                            }
                        },
                        "endOfWord": false
                    }
                },
                "endOfWord": false
            }
        },
        "endOfWord": false
    }
}
return None
output: [None, None]

Operation 3: "search" Word: "apple"
return True
output: [None,None,True]

Operation 4: "search" Word: "app"
return False
ouput: [None,None,True, False]
```

```
Operation 5: "startsWith" Word: "app"
return True
output: [None,None,True,False,True]

Operation 6: "insert" Word: "app"
return None
output: [None,None,True,False,True, None]
Tree:{
    "root": {
        "children": {
            "a": {
                "children": {
                    "p": {
                        "children": {
                            "p": {
                                "children": {
                                    "l": {
                                        "children": {
                                            "e": {
                                                "children": {},
                                                "endOfWord": true
                                            }
                                        },
                                        "endOfWord": false
                                    }
                                },
                                "endOfWord": True
                            }
                        },
                        "endOfWord": false
                    }
                },
                "endOfWord": false
            }
        },
        "endOfWord": false
    }
}

Operation 7: "search" Word: "app"
return True
output: [None,None,True,False,True, None, True]
```

Alternate Solution: Using dictionary

```
class Trie(object):
    def __init__(self):
        self.data = {"children": {},"endOfWord":False}
    def insert(self,word):
        current_node = self.data
        for char in word:
            if char not in current_node["children"]:
                current_node["children"][char] = {"children": {},"endOfWord":False}
            current_node = current_node["children"][char]
        current_node["endOfWord"] = True

    def search(self,word):
        current = self.data
        for c in word:
                if c not in current['children']:
                        return False
                current = current['children'][c]
        return current['endOfWord']

    def startsWith(self,prefix):
                #start from the root
                current = self.data
                #for every character in the prefix
                for c in prefix:
                        #if character is in children or not
                        if c not in current["children"]:
                                return False # not a prefix
                        #move to the next child
                        current = current["children"][c]
                #if that for loop ends without returning that means we've checked all the characters
                return True

obj = Trie()
param1 = ["Trie","insert","search","search","startsWith","insert","search"]
param2 = [[],["apple"],["apple"],["app"],["app"],["app"],["app"]]
output = []
operations={
    "Trie":None,
    "insert": obj.insert,
    "search": obj.search,
    "startsWith": obj.startsWith
}
for i in range(len(param1)):
    method = operations[param1[i]]
    if method is not None:
        output.append(method(param2[i][0]))
    else:
        output.append(None)
print(output)
```

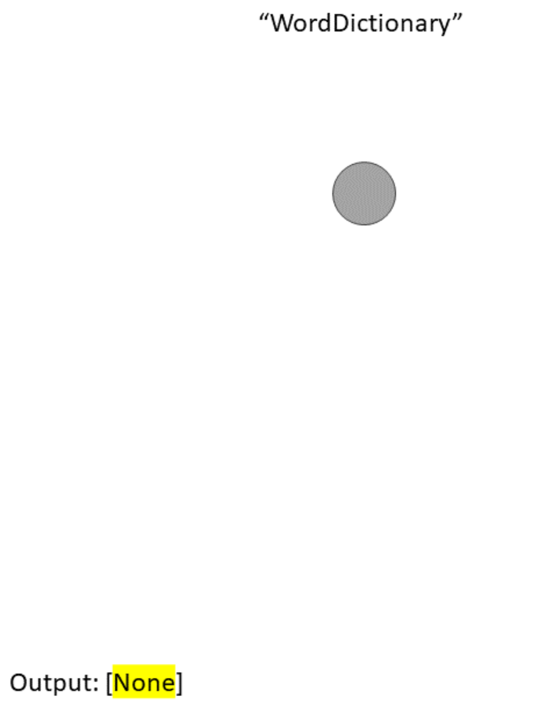
Problem: 2 Leetcode Design Add And Search Words Data Structure

Medium

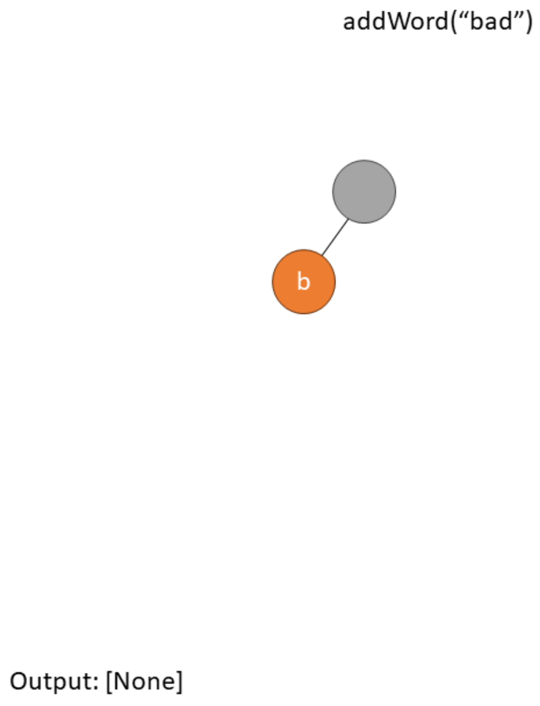
```
class TrieNode():
    def __init__(self):
        self.children = {}
        self.isWord = False
class WordDictionary(object):
    def __init__(self):
        self.root = TrieNode()

    def addWord(self, word):
        current = self.root
        for c in word:
            if c not in current.children:
                current.children[c] = TrieNode()
            current = current.children[c]
        current.isWord = True

    def search(self, word):

        def dfs(i,root):
            current = root
            for i in range(i,len(word)):
                if word[i] == ".":
                    for child in current.children.values():
                        if dfs(i+1, child):
                            return True
                if word[i] not in current.children:
                    return False
                current=current.children[word[i]]
            return current.isWord

        return dfs(0, self.root)

obj = WordDictionary()
param1=["WordDictionary","addWord","addWord","addWord","search","search","search","search"]
param2=[[],["bad"],["dad"],["mad"],["pad"],["bad"],[".ad"],["b.."]]
output = []
operations={
                        "WordDictionary":None,
                        "addWord": obj.addWord,
                        "search": obj.search
                        }
for i in range(len(param1)):
        method = operations[param1[i]]
        if method is not None:
                output.append(method(param2[i][0]))
        else:
                output.append(None)
print(output)
```

```
>>> [None, None, None, None, False, True, True, True]
```

Explanation

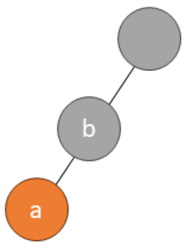

“WordDictionary”

Output: [None]


addWord(“bad”)

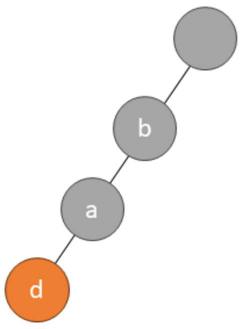
Output: [None]

addWord(“bad”)



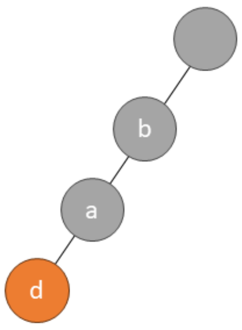
Output: [None]

addWord(“bad”)



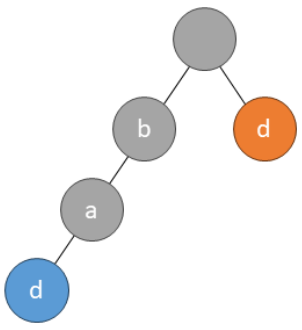
Output: [None]

addWord(“bad”)



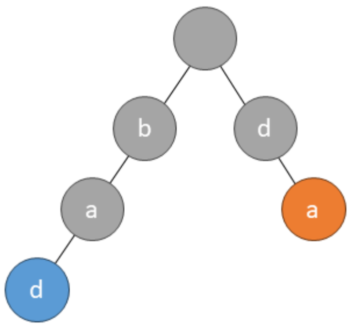
Output: [None]

addWord(“dad”)



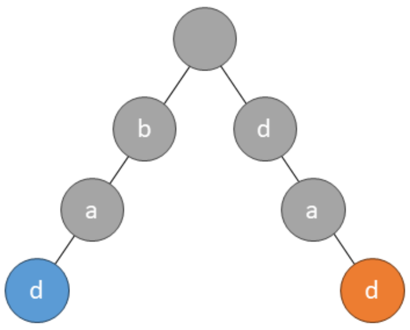
Output: [None, None]

addWord(“dad”)



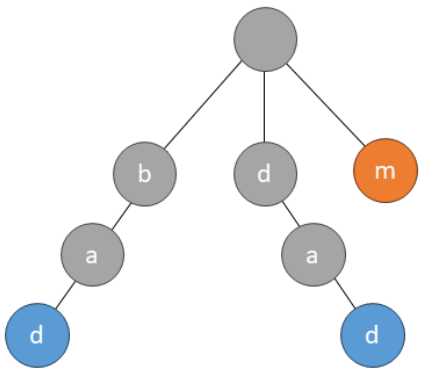
Output: [None, None]

addWord(“dad”)



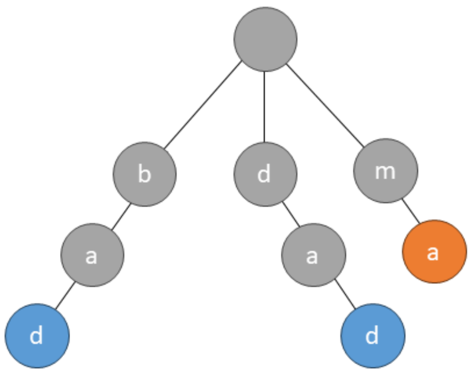
Output: [None, None]

addWord(“mad”)



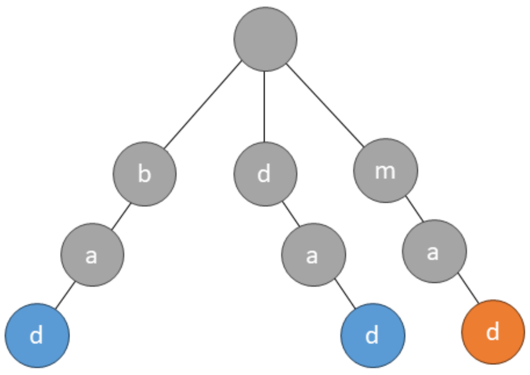
Output: [None, None, None]

addWord(“mad”)



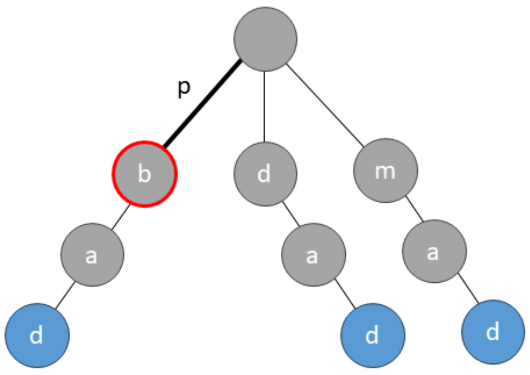
Output: [None, None, None]

addWord(“mad”)



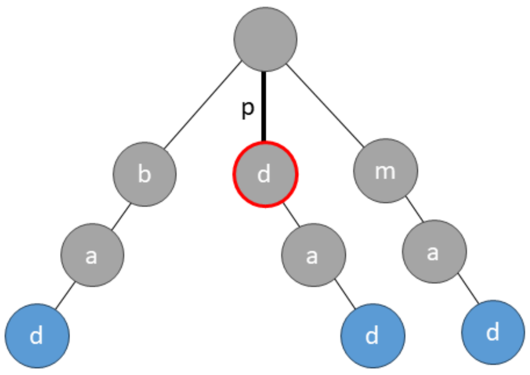
Output: [None, None, None, None]

search(“pad”)



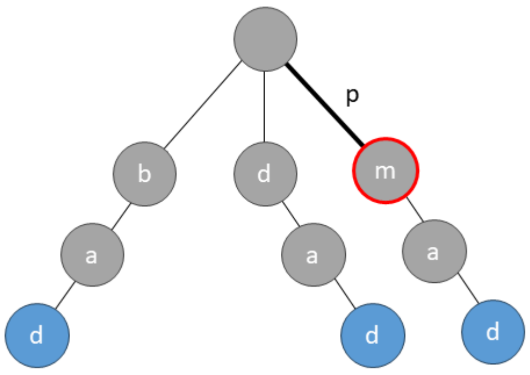
Output: [None, None, None, None]

search(“pad”)



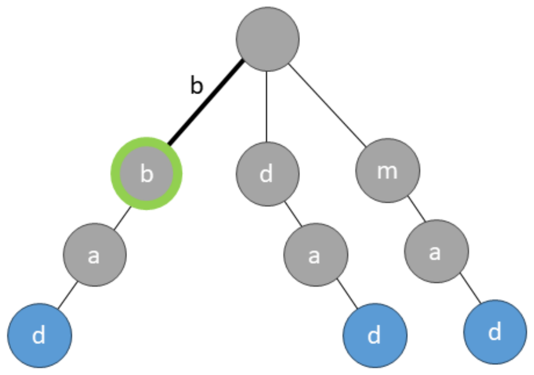
Output: [None, None, None, None]

search(“pad”)



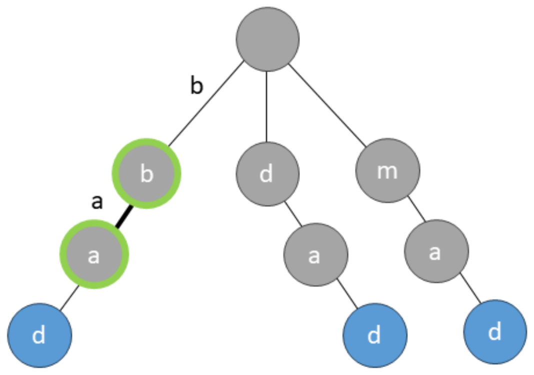
Output: [None, None, None, None, False]

search(“bad”)



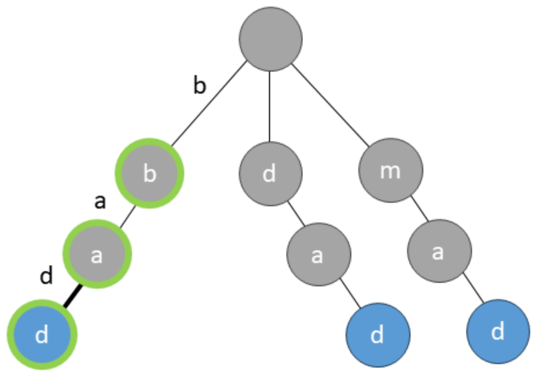
Output: [None, None, None, None, False]

search(“bad”)

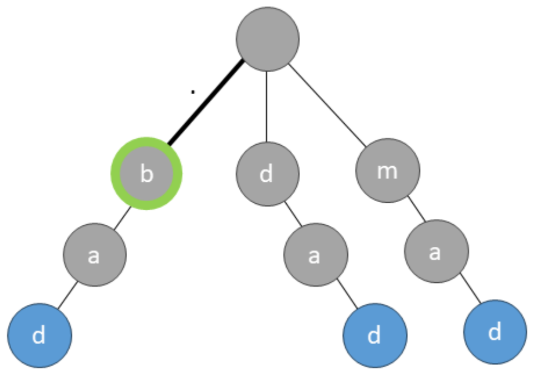


Output: [None, None, None, None, False]

search(“bad”)

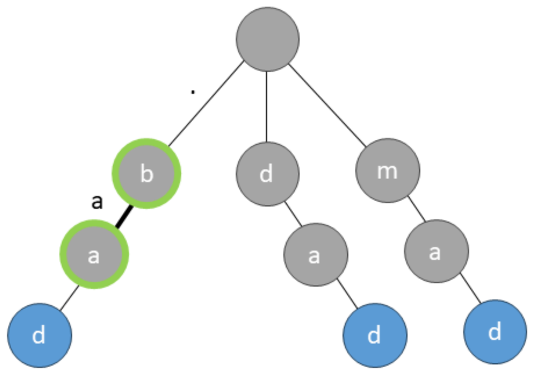


Output: [None, None, None, None, False, True] search(“.ad”)



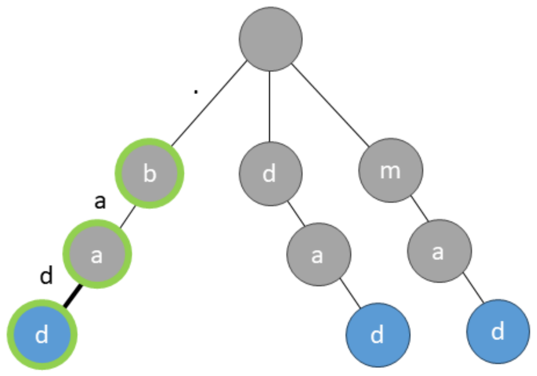
Output: [None, None, None, None, False, True]

search(“.ad”)

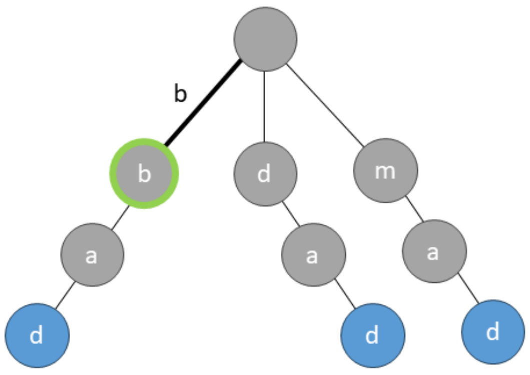


Output: [None, None, None, None, False, True]

search(“.ad”)

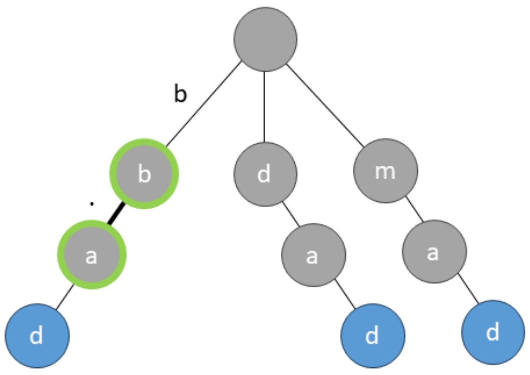


Output: [None, None, None, None, False, True, True] search(“b..”)



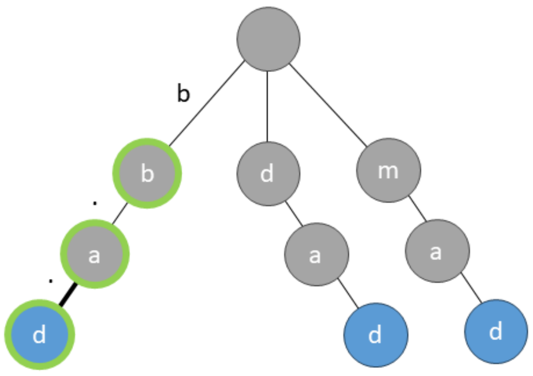
Output: [None, None, None, None, False, True, True]

search(“b..”)



Output: [None, None, None, None, False, True, True]

search(“b..”)



Output: [None, None, None, None, False, True, True, True]

Problem 3: Leetcode - Word Search II

#word_search_II

Hard

```
class TrieNode():
        def __init__(self):
                self.children = {}
                self.isWord = False
        def addWord(self, word):
                cur = self
                for c in word:
                        if c not in cur.children:
                                cur.children[c] = TrieNode()
                        cur = cur.children[c]
                cur.isWord = True
class WordSearch(object):
        def findWords(self, board, words):
                root = TrieNode()
                for w in words:
                        root.addWord(w)
                ROWS, COLS = len(board),len(board[0])
                res, visited = set(), set()
                def dfs(r, c, node, word):
                        if (r<0 or c<0 or
                                c == COLS or r == ROWS or
                                (r,c) in visited or
                                board[r][c] not in node.children):
                                #if the current position is out of bounds or visited or not a child node
                                return
                        if node.children == {}:
                                return
                        visited.add((r,c))

                        node = node.children[board[r][c]]
                        word += board[r][c]
                        # if current node isWord then we add it to the result
                        if node.isWord == True:
                                res.add(word)
                        dfs(r-1,c, node, word) #down
                        dfs(r+1,c, node, word) #up
                        dfs(r,c+1, node, word) #right
                        dfs(r,c-1, node, word) #left
                        visited.remove((r,c))
                for r in range(ROWS):
                        for c in range(COLS):
                                dfs(r,c,root,"")

                return list(res)

board = [["o","a","a","n"],["e","t","a","e"],["i","h","k","r"],["i","f","l","v"]]
words = ["oath","pea","eat","rain"]
obj = WordSearch()
print(obj.findWords(board, words))
```

Explanation

Question 1: What does the 'addWord' function do?

```
        {
    "root": {
        "children": {
            "o": {
                "children": {
                    "a": {
                        "children": {
                            "t": {
                                "children": {
                                    "h": {
                                        "children": {},
                                        "endOfWord": true
                                    }
                                },
                                "endOfWord": false
                            }
                        },
                        "endOfWord": false
                    }
                },
                "endOfWord": false
            },
            "p": {
                "children": {
                    "e": {
                        "children": {
                            "a": {
                                "children": {},
                                "endOfWord": true
                            }
                        },
                        "endOfWord": false
                    }
                },
                "endOfWord": false
            },
            "e": {
                "children": {
                    "a": {
                        "children": {
                            "t": {
                                "children": {},
                                "endOfWord": true
                            }
                        },
                        "endOfWord": false
                    }
                },
                "endOfWord": false
            },
            "r": {
                "children": {
                    "a": {
                        "children": {
                            "i": {
                                "children": {
                                    "n": {
                                        "children": {},
                                        "endOfWord": true
                                    }
                                },
                                "endOfWord": false
                            }
                        },
                        "endOfWord": false
                    }
                },
                "endOfWord": false
            }
        },
                "endOfWord": false
            }
        },
        "endOfWord": false
    }
}
```

Question 2: How does the grid traversal work?

---

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

start:

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

`output: ["oath"]`

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

Then eventually:

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

o	a	a	n
e	t	a	e
i	h	k	r
i	f	l	v

`output: ["oath","eat"]`

End