Trie

“Prefix Tree”

Prerequisite: Recursion, Tree

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How many words are there in Dictionary?

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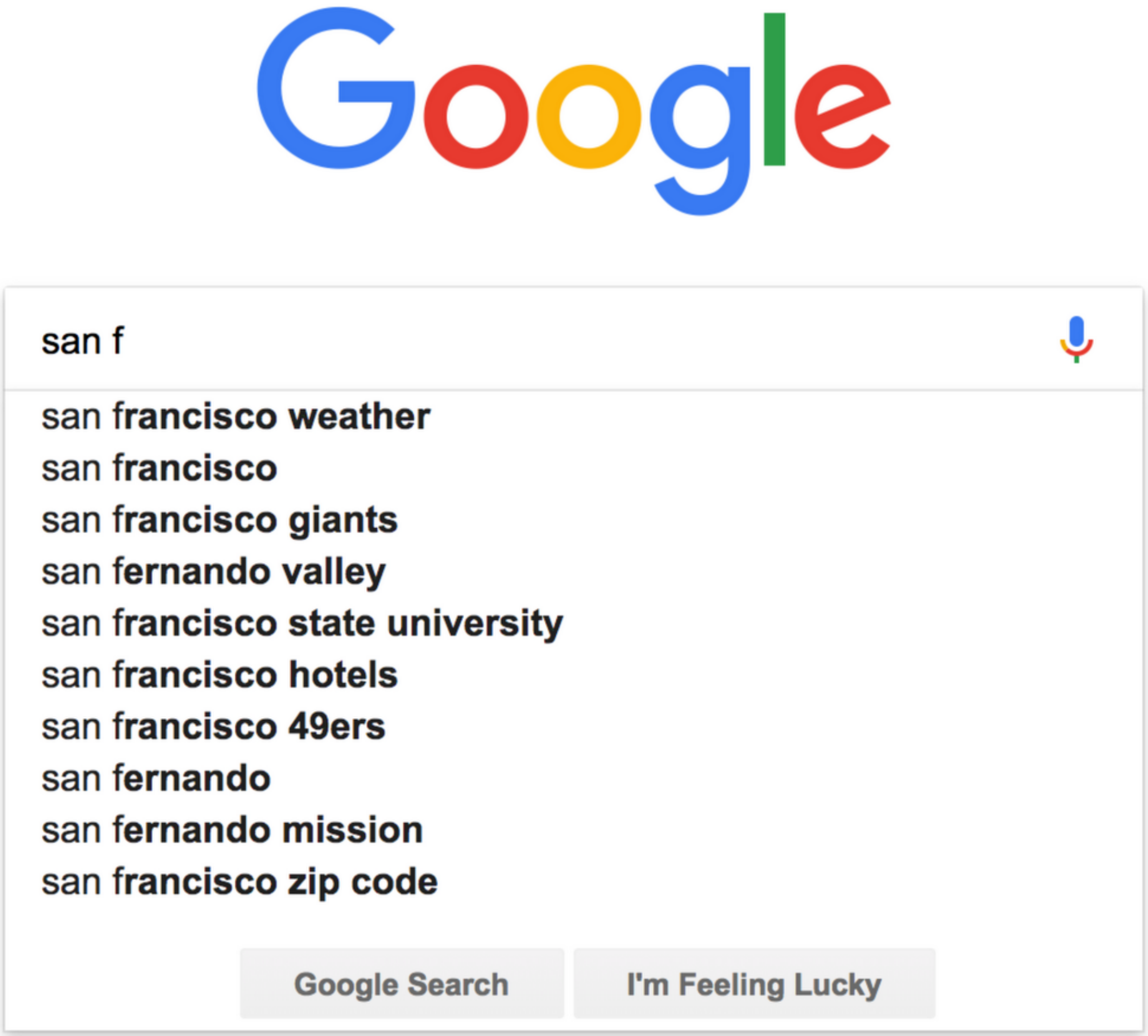
The 20-volume Oxford English Dictionary contains full entries for 1,71,476 words in current use, and 47,156 obsolete words

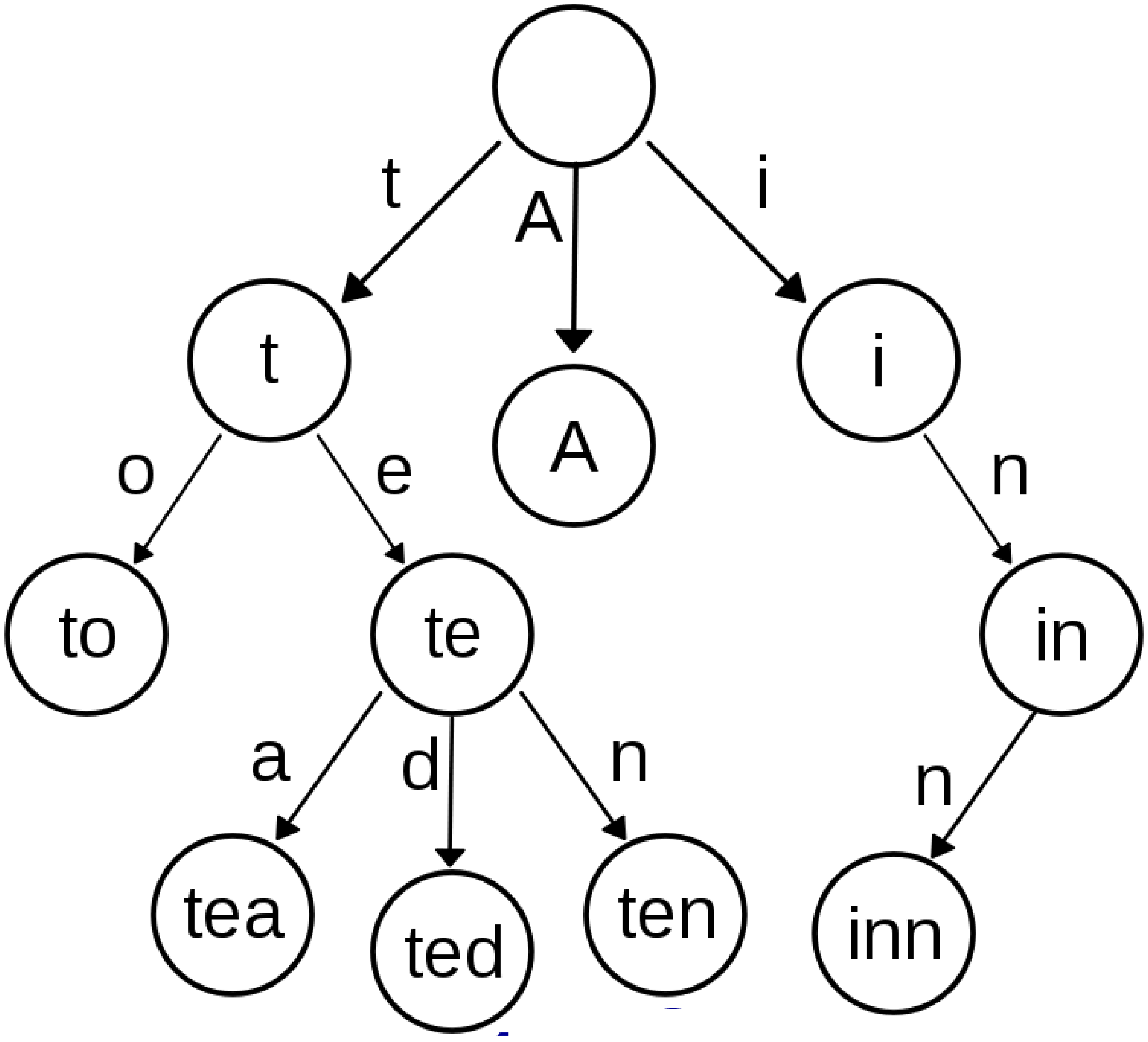
How many words are there in the Internet?



san f

san francisco weather
san francisco
san francisco giants
san fernando valley
san francisco state university
san francisco hotels
san francisco 49ers
san fernando
san fernando mission
san francisco zip code

Tree for Retrieval



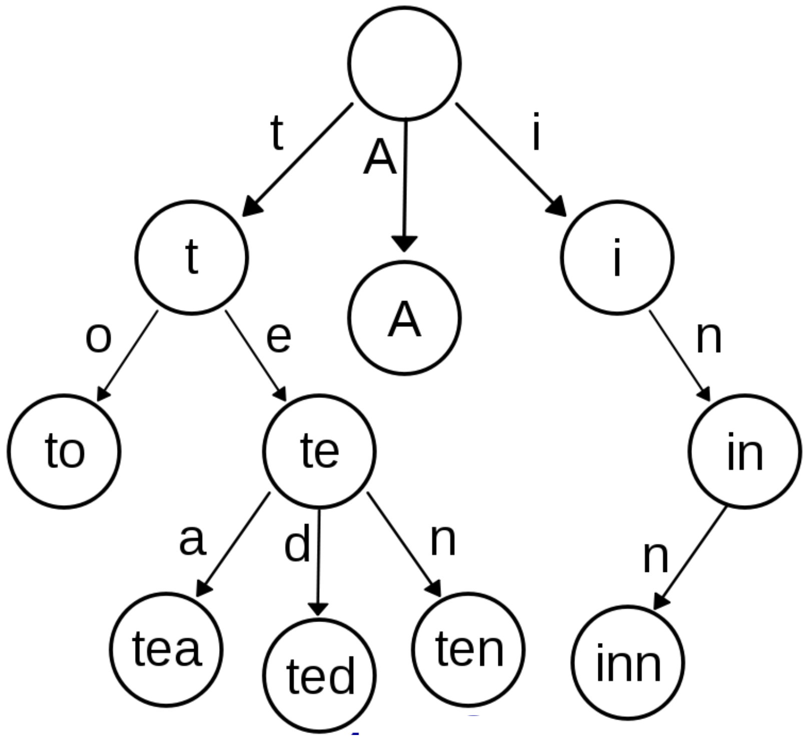
Node Structure

Node
`Node * children[SIZE_OF_ALPHABET];`
`bool isLeaf;`

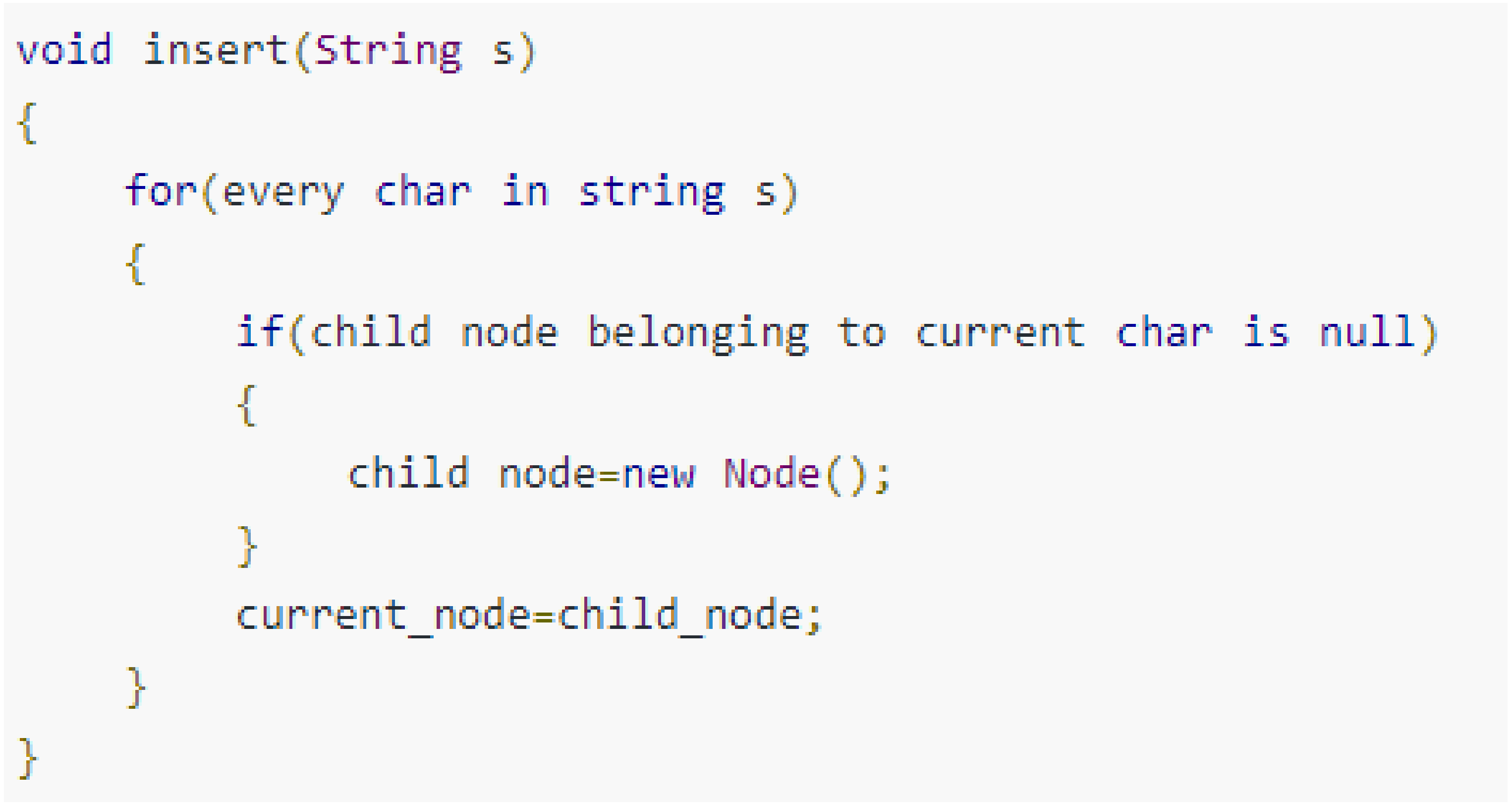
Task

Insert the following words in a Trie

- Car
- Carbon
- Carpet
- Carbide
- Carpal



Insertion



```
void insert(String s)
{
    for(every char in string s)
    {
        if(child node belonging to current char is null)
        {
            child node=new Node();
        }
        current_node=child_node;
    }
}
```

Insertion

```
void insert(struct TrieNode *root, string key)
{
    struct TrieNode * temp = root;

    for (int i = 0; i < key.length(); i++)
    {
        int index = key[i] - 'a';
        if (!temp->children[index])
            temp->children[index] = getNode();

        temp = temp->children[index];
    }

    temp->isEndOfWord = true;
}
```

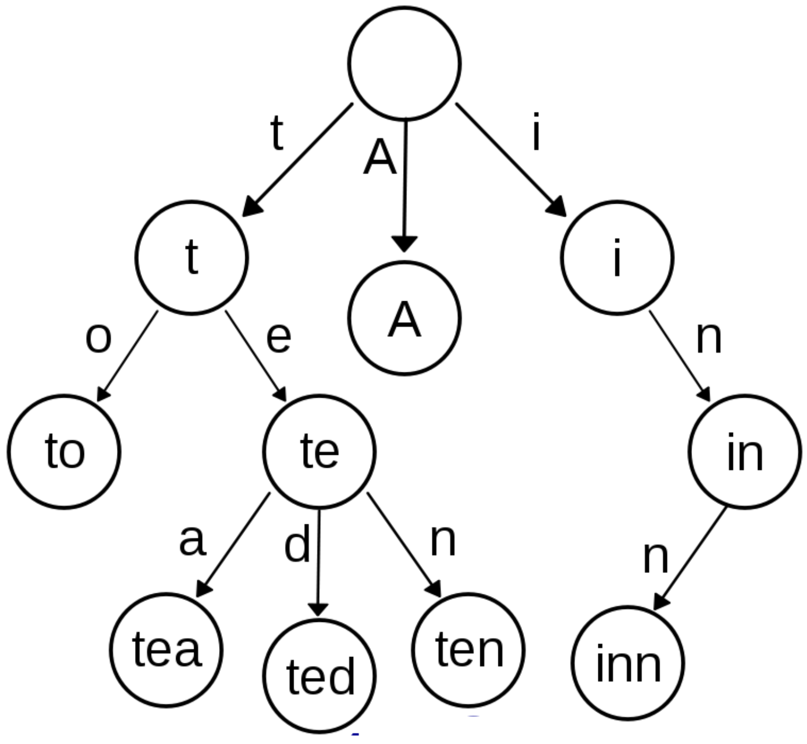
Recursive Insertion

```
void insertRecursively(trie* itr, string str, int i)
{
    if(i < str.length())
    {
        int index = str[i] - 'a';
        if(itr->child[index] == NULL )
        {
            itr->child[index] = createNode();
        }
        insertRecursively(itr->child[index], str, i+1);
    }
    else
    {
        itr->endOfWord = true;
    } ;
}
void insert(trie* itr, string str)
{
    insertRecursively(itr, str, 0)
}
```

Task

Insert the following words in a Trie

- a
- answer
- any
- by
- bye
- the
- their
- there



Display

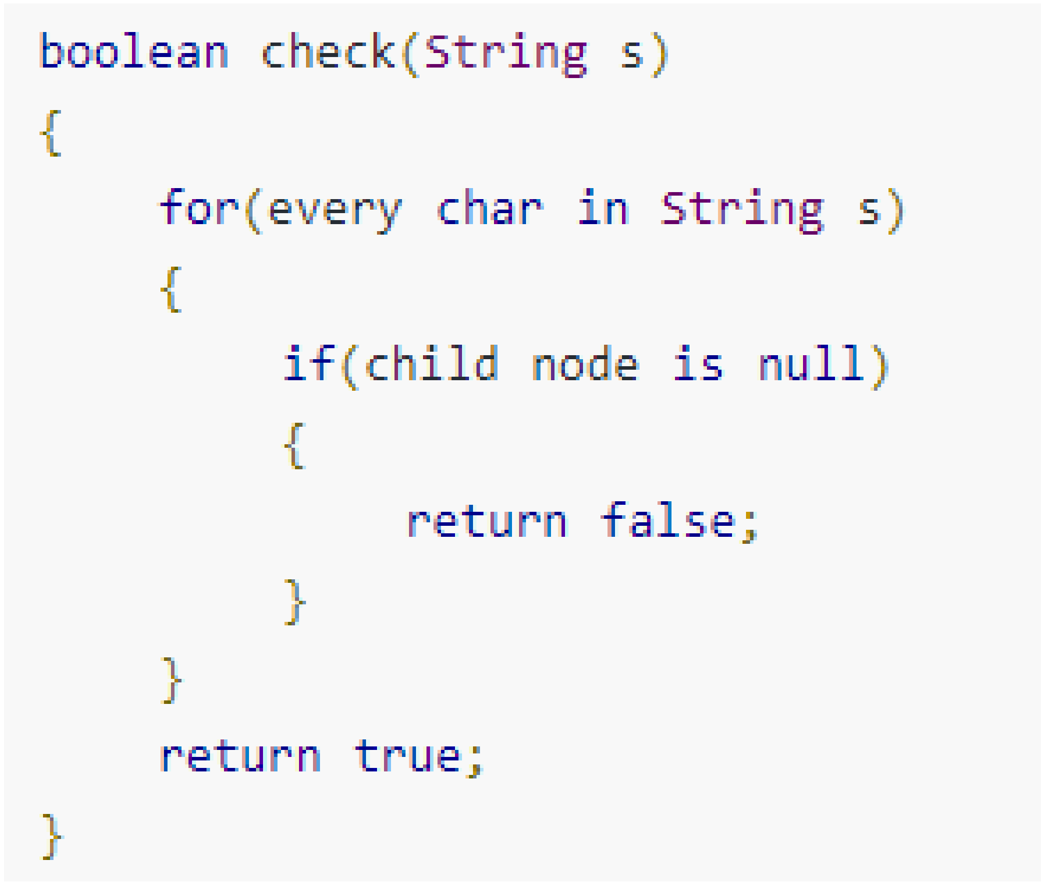
Perform Pre-order traversal in Trie

Display

Perform Pre-order traversal in Trie

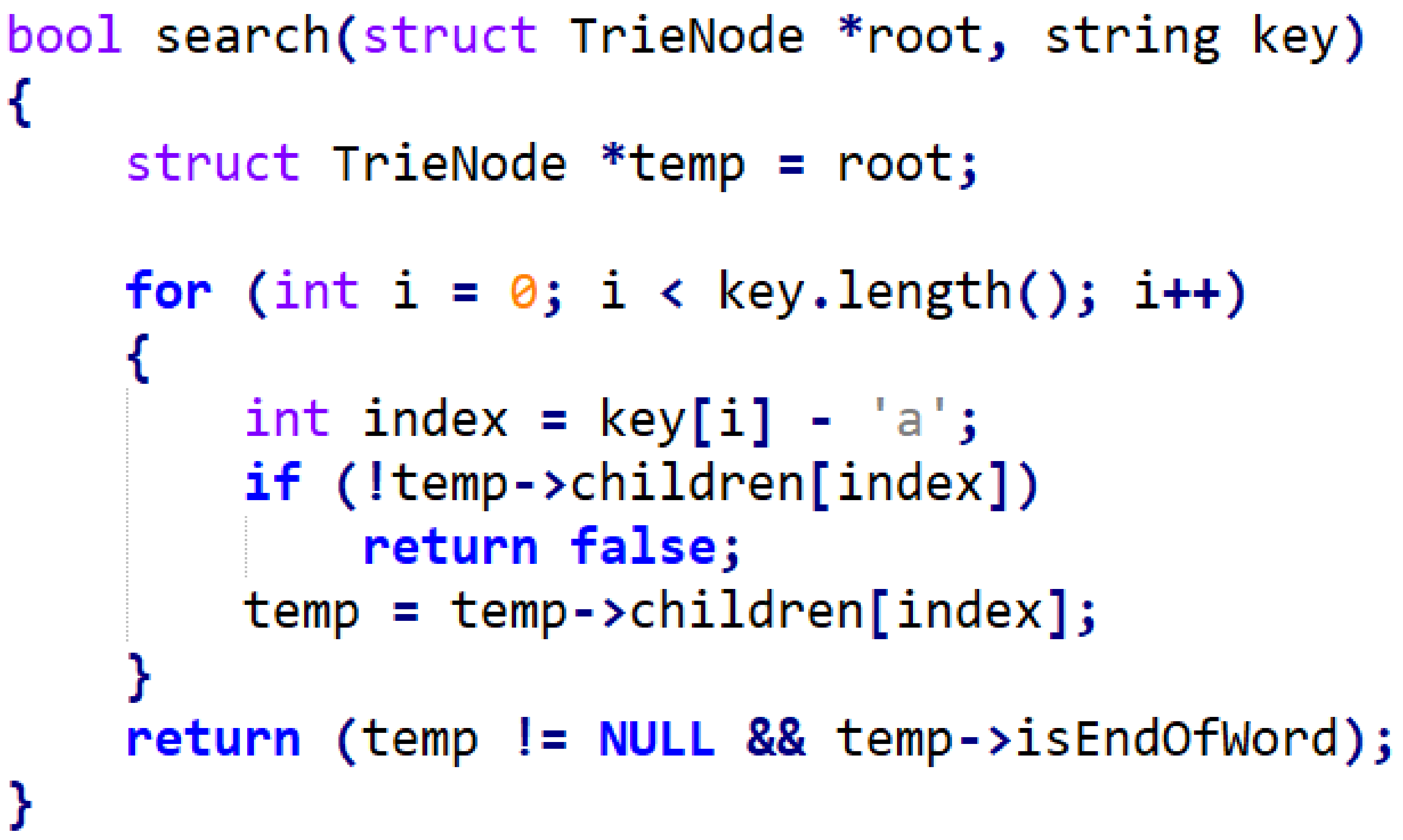
```
void display(struct TrieNode* root, char str[], int level)
{
    if (isLeafNode(root))
    {
        str[level] = '\0';
        cout << str << endl;
    }
    for (int i = 0; i < alpha_size; i++)
    {
        if (root->children[i])
        {
            str[level] = i + 'a';
            display(root->children[i], str, level + 1);
        }
    }
}
```

Search



```
boolean check(String s)
{
    for(every char in String s)
    {
        if(child node is null)
        {
            return false;
        }
    }
    return true;
}
```

Search



```
bool search(struct TrieNode *root, string key)
{
    struct TrieNode *temp = root;

    for (int i = 0; i < key.length(); i++)
    {
        int index = key[i] - 'a';
        if (!temp->children[index])
            return false;
        temp = temp->children[index];
    }
    return (temp != NULL && temp->isEndOfWord);
}
```

Deletion

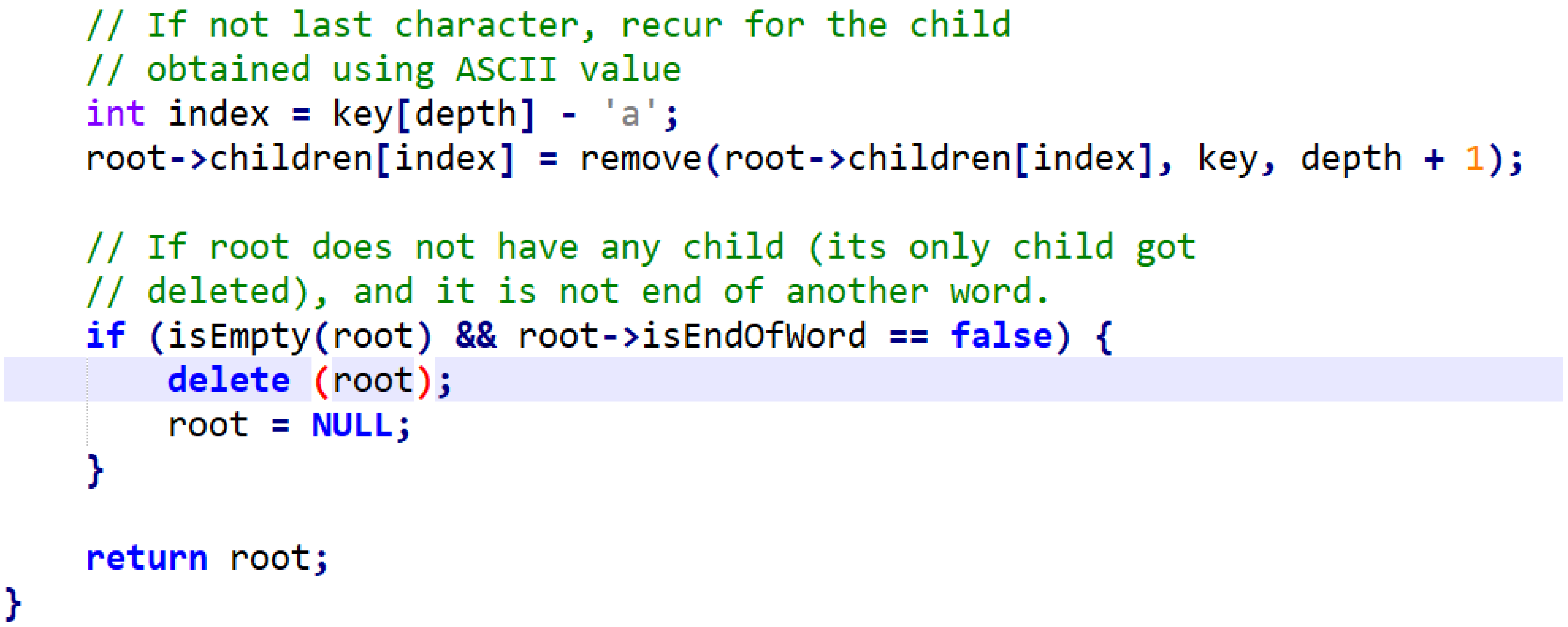
Possible Cases

1. Key may not be there in trie. Delete operation should not modify trie.
2. Key present as unique key (no part of key contains another key (prefix), nor the key itself is prefix of another key in trie). Delete all the nodes.
3. Key is prefix key of another long key in trie. Unmark the leaf node.
4. Key present in trie, having atleast one other key as prefix key. Delete nodes from end of key until first leaf node of longest prefix key.

Deletion

```
TrieNode* remove(TrieNode* root, string key, int depth = 0)
{
    if (!root)
        return NULL;

    if (depth == key.size()) {

        if (root->isEndOfWord)
            root->isEndOfWord = false;

        if (isEmpty(root)) {
            delete (root);
            root = NULL;
        }
        return root;
    }
```

Deletion

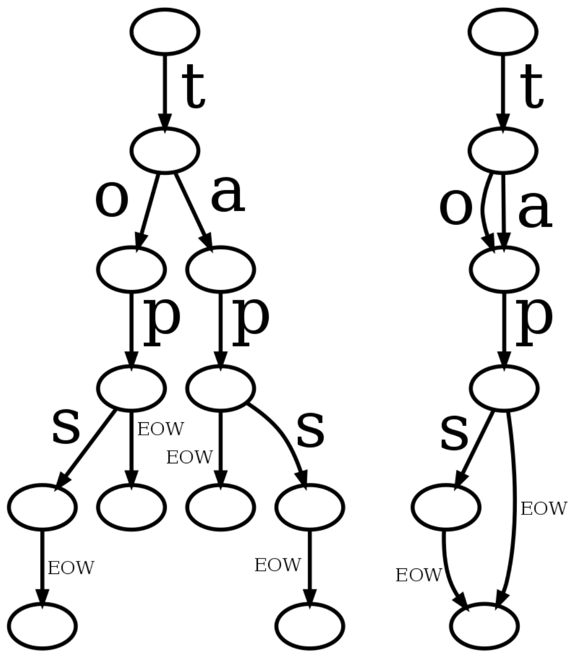


```
    // If not last character, recur for the child
    // obtained using ASCII value
    int index = key[depth] - 'a';
    root->children[index] = remove(root->children[index], key, depth + 1);

    // If root does not have any child (its only child got
    // deleted), and it is not end of another word.
    if (isEmpty(root) && root->isEndOfWord == false) {
        delete (root);
        root = NULL;
    }

    return root;
}
```

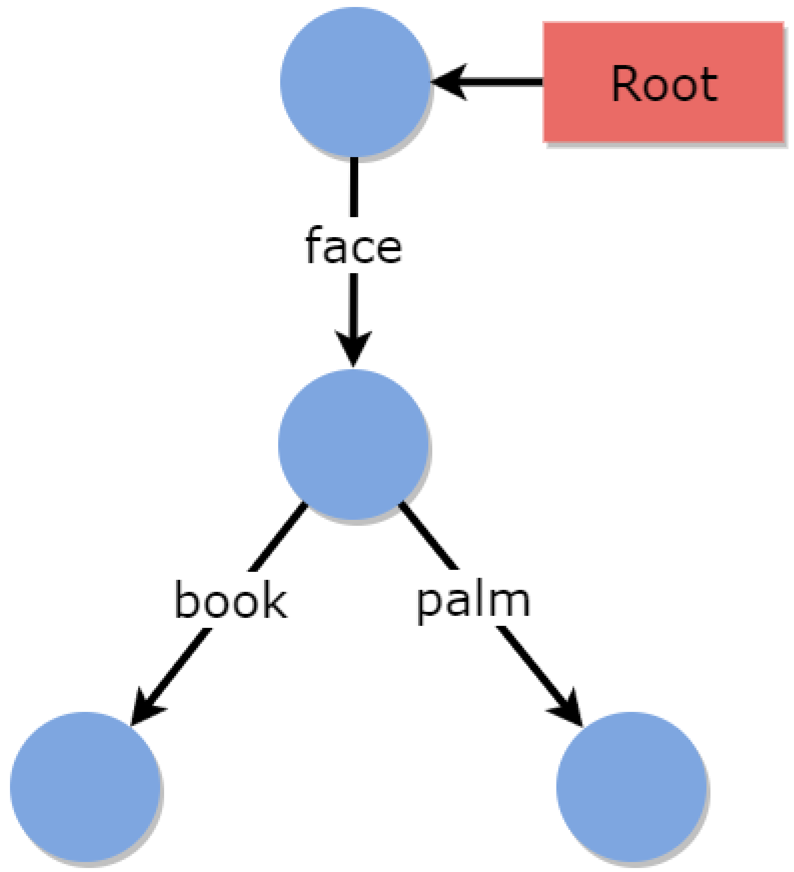
Compressing the Trie

A few techniques:

1. Keep only the pointers that are needed
2. Sort the pointers based on frequency
3. Use heuristic (‘u’ almost always comes after ‘q’)
4. Use Directed Acyclic Word Graph
5. Radix Tree



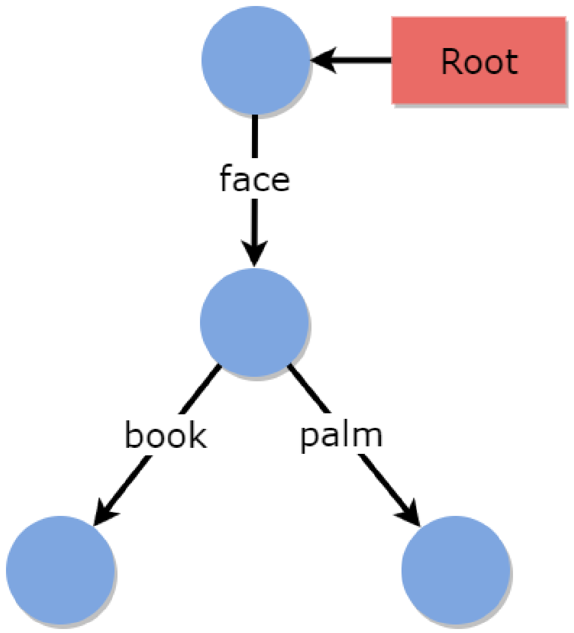
Compressing the Trie



Compressing the Trie

Node for Regular Trie

```java
class Node {
    Node[] children = new Node[26];
    boolean isWordEnd;
}
```

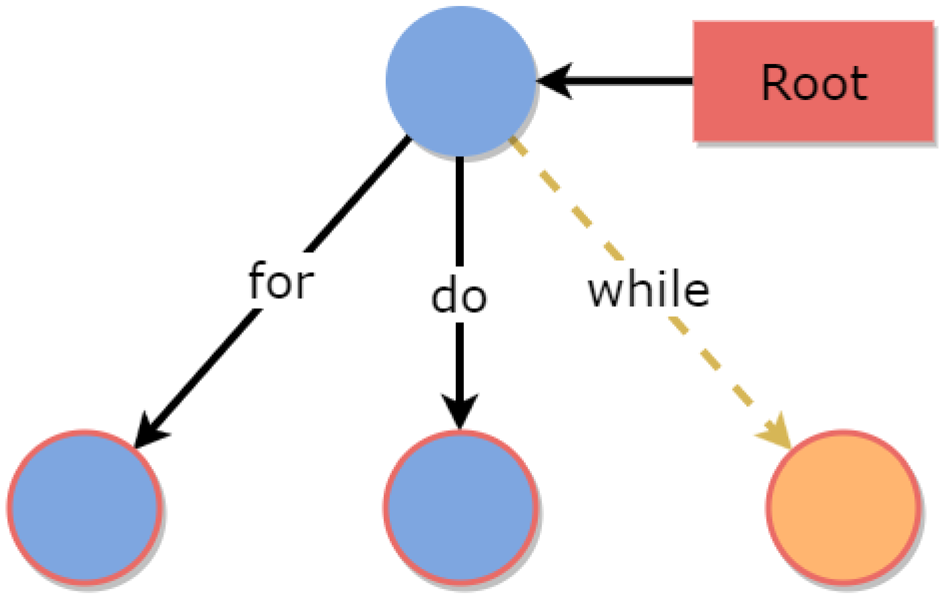


Node for Compressed Trie

```java
class Node {
    Node[] children = new Node[26];
    StringBuilder[] edgeLabel = new StringBuilder[26];
    boolean isEnd;
}
```

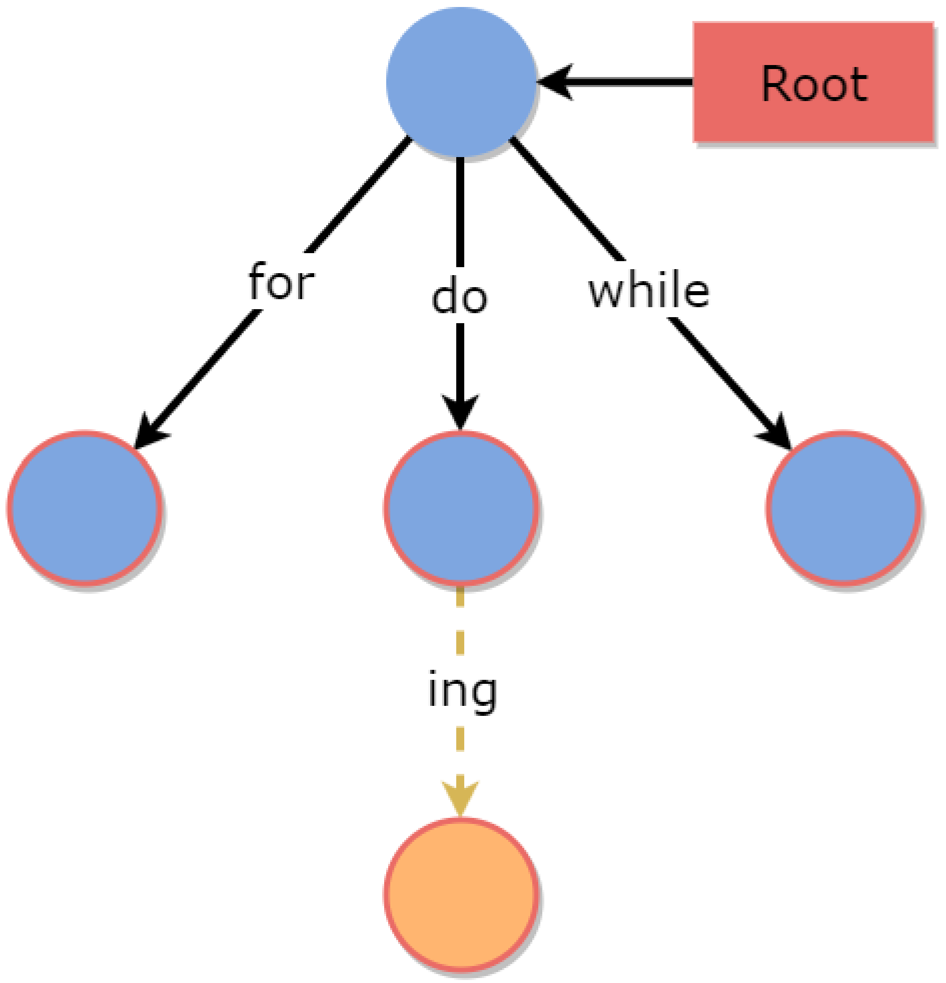
Insertion

Inserting "while"
when "for" and "do"
are already inserted

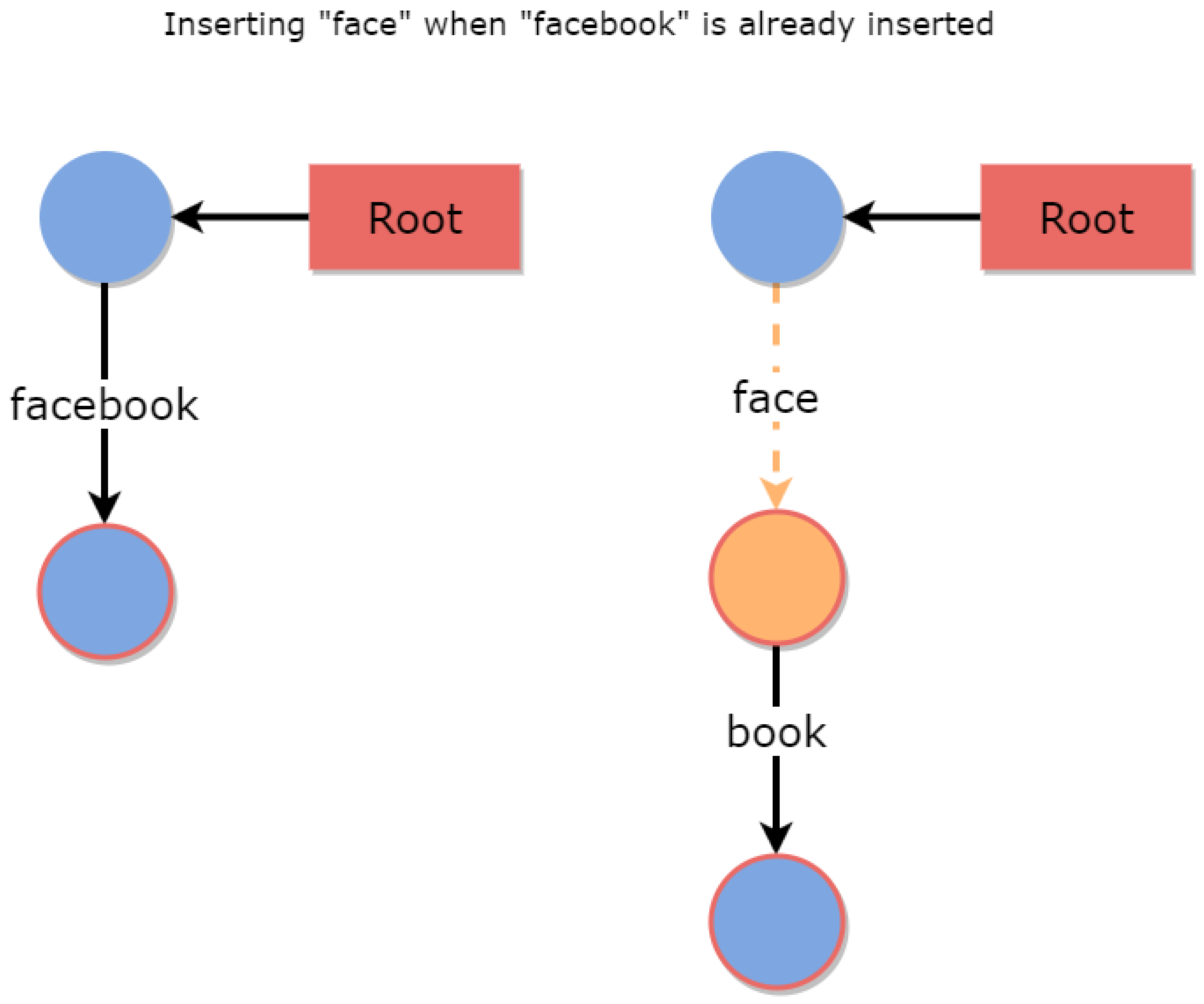


Insertion

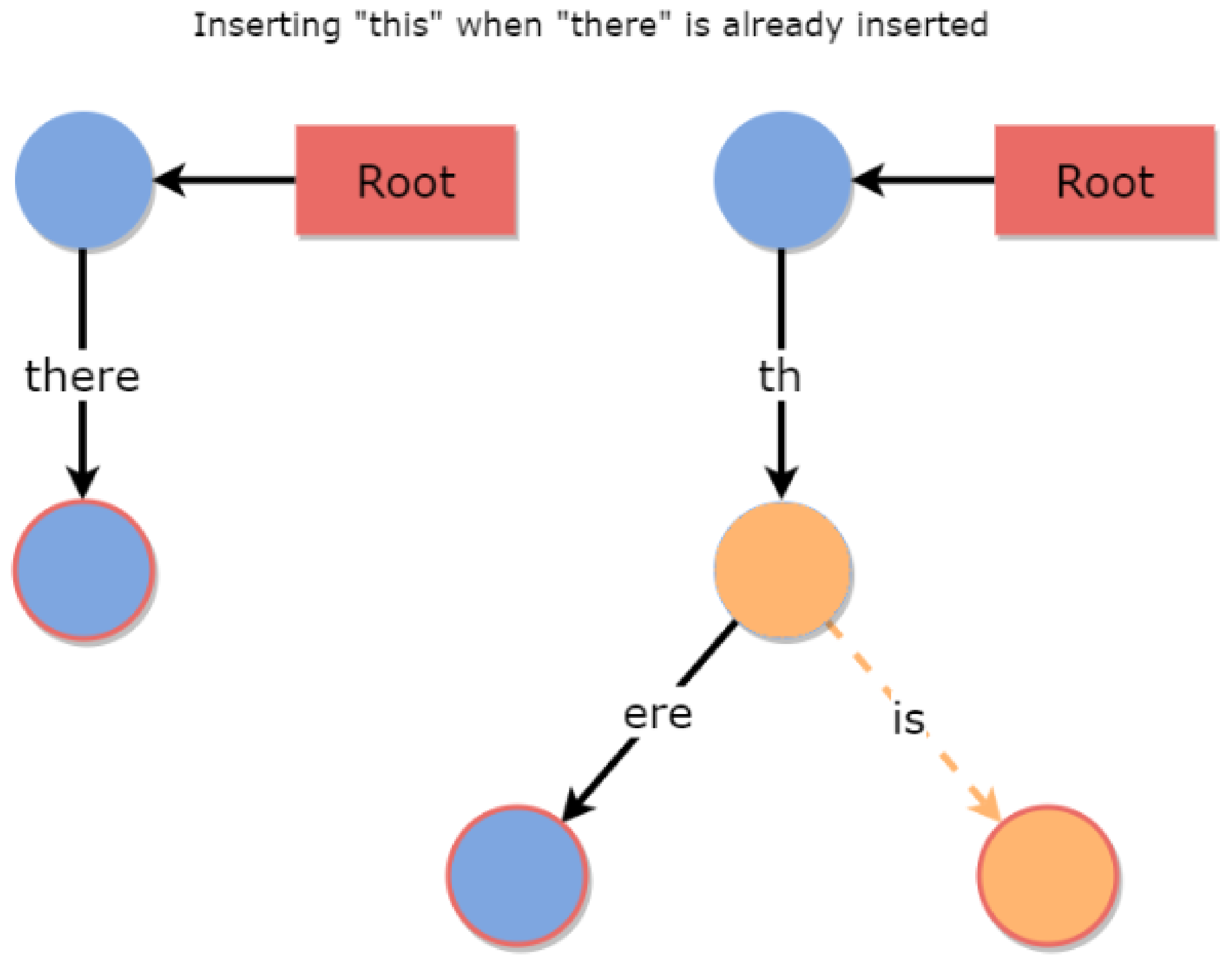
Inserting "doing" when "for", "do" and "while" are already inserted



Insertion


Inserting "face" when "facebook" is already inserted
Root
facebook
Root
face
book

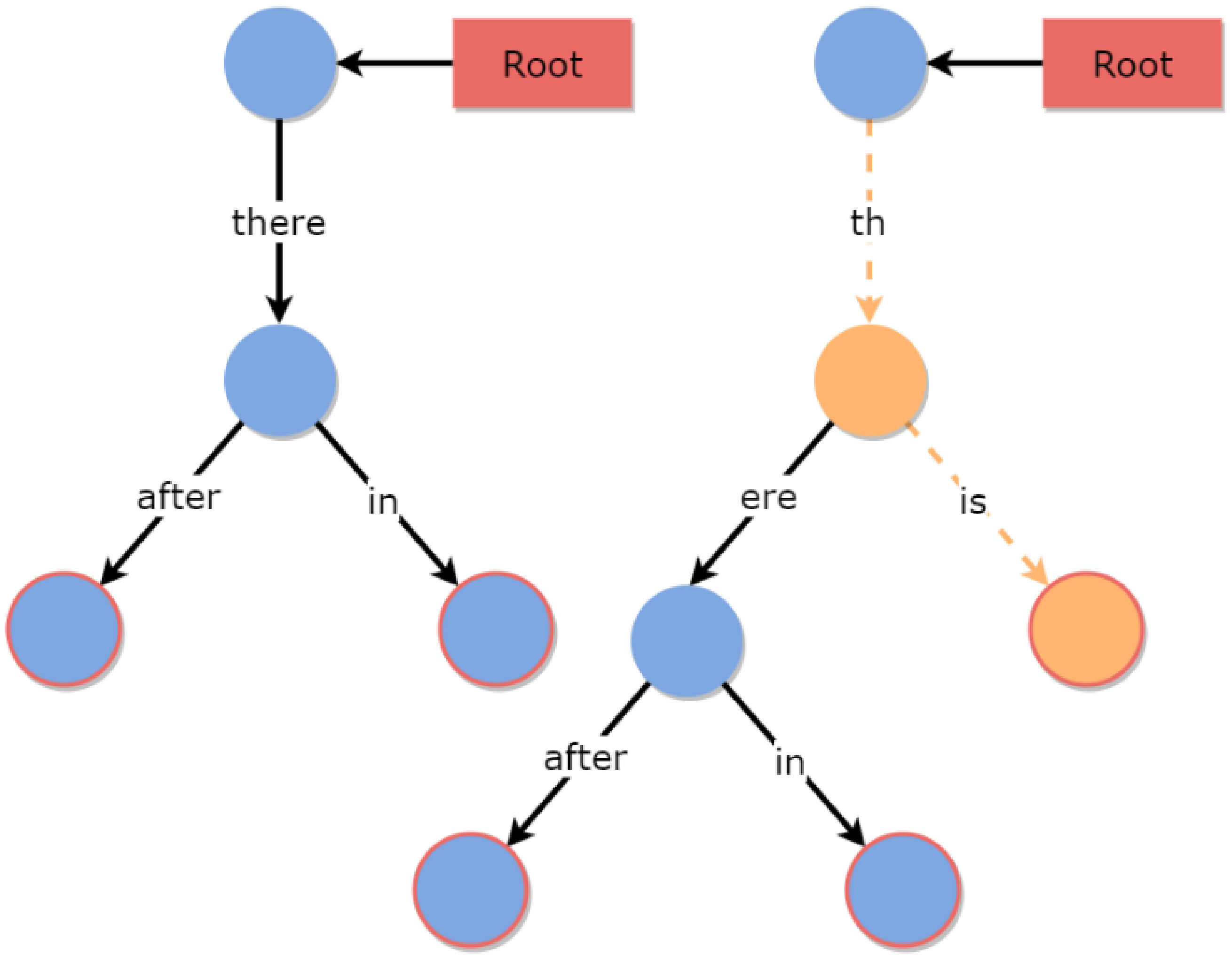
Insertion



Inserting "this" when "there" is already inserted
Root
there
Root
th
ere
is

Insertion

Inserting "this" when "thereafter" and "therein" are already inserted



Reference

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