

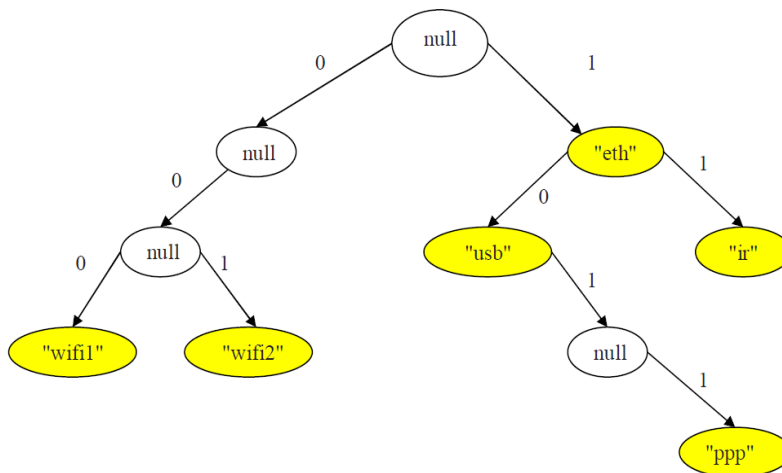
## Top-20 Training Program (Trie & Bloom Filter)

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Apply the Trie and BloomFilter data structures discussed in class to solve the following problems.

### Problem1: Routing Table Implementation

The figure below illustrates a trie that stores the bit string keys: 1, 11, 10, 1011, 000, 001. In this binary tree a move to the left denotes a 0 and a move to the right denotes a 1. Thus, when searching for a key  $a = a_0a_1a_2... a_n$ , we go left at a node of depth  $i$  if  $a_i = 0$  and right if  $a_i = 1$ . Not all the nodes in the tree represent key-value pairs. Some nodes represent only unique prefixes common to several keys ("0", "00" and "101") and are essential for establishing a path to other nodes. In the figure below, only the yellow nodes represent key-value pairs. One should note that there is no need to actually store the keys in the nodes, since they can be inferred by traversing the path from the root to the node (but there is a need to define that a node represents a key).



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```
t = new RoutingTable();  
t.add(10000000....b,1,"eth");  
t.add(11000000....b,2,"ir");  
t.add(10000000....b,2,"usb");  
t.add(10110000....b,4,"ppp");  
t.add(00000000....b,3,"wifi1");  
t.add(00100000....b,3,"wifi2");
```

On this object, the query `t.route(01000000....b)` should throw an exception, and the query `t.route(10101111....b)` should return `"usb"`. Assume that each input argument to add and route methods is 32-bit integer and shown here in binary form for better understanding and while storing the key in trie, you have to store the first n bits of that integer only.

### Problem2: T9 Predictive Text Implementation

In this problem, you have to implement T9 predictive text, a text input mode available on cellphones. On a cellphone, each number from 2-9 on the keypad represent three or four letters, the number 0 represents a space, and 1 represents a set of symbols such as { , . ! ? } etc. The numbers from 2-9 represent letters as follows:

2 ABC  
3 DEF  
4 GHI  
5 JKL  
6 MNO  
7 PQRS  
8 TUV  
9 WXYZ

Since multiple letters map to a single number, many key sequences represent multiple words. For example, the input 2665 represents "book" and "cool", among other possibilities.

Write a class `T9Prediction` class with the constructor doing the following functionality: It should read in a dictionary file that contains a list of words and translate each word in the dictionary into its numeric key sequence, then add the key sequence to your trie, with the word at the end of the path corresponding to the digits. If a word with the same numeric sequence already exists in the trie, add the new word as part of linked list at that node. You can download the dictionary file named "dictionary.txt" from algorithmica github



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### Problem3: URL Filter

Your URL filter will take in URL(s) as input parameters and determine whether they match a blacklist of bad URLs. Your web filter should implement the URLFilter interface that we provide. You should assume that the input source for blacklists is a newline-separated file of URLs.

- **void clearFilter():** empty the web filter blacklist
- **void addBlacklist(<blacklist file>):** add the URLs from the file specified to the URL filter.
- **void filter(<input urls>, <filtered\_urls>):** read URLs from the input urls file. For each URL that is in the web filter, add it to a newline-separated output file specified by filtered urls.
- **void perf(<input urls>,<n>):** read up to n URLs from the input urls file. Determine whether each URL is in the filter and report how many passed the filter, along with the total time taken in milliseconds. If n is larger than the number of URLs in the input, the existing URLs are reused repeatedly until n total URLs have been tested.

### Problem4: Book Index

Write a program to determine, given a large text file, all of the line numbers (zero-based) on which each word appears. Specifically, write a class Index, the constructor of which builds a trie associating each word with a Queue of the line numbers (0-based) on which it appears. The get() method returns the Queue associated with a particular word (or null if that word never appears).