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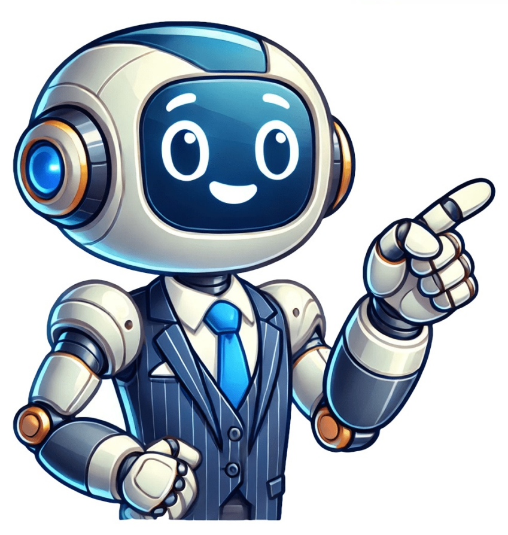

Seems like cookies are disabled on this browser, please enable them to open this website It includes AI that generates DSA solutions in four languages: C, C++, Java, and Python. Seems like cookies are disabled on this browser, please enable them to open this website Source: Update 18 October 2019: I have created a curation of Leetcode problems which I personally use to prepare for technical interviews. Stars are welcome, and feel free to fork it for your own modification and use! Ill be adding more questions in time! :)If youre looking for a new job, use Triplebyte to interview once and apply to multiple top tech companies!This post draws on my personal experiences and challenges over the past term at school, which I entered with hardly any knowledge of DSA (data structures and algorithms) and problem-solving strategies. As a self-taught programmer, I was a lot more familiar and comfortable with general programming, such as object-oriented programming, than with the problem-solving skills required in DSA questions.This post reflects my journey throughout the term and the resources I turned to in order to quickly improve my data structures, algorithms, and problem-solving skills.Problem: You know the theory, but you get stuck on practical applicationsI faced this issue early in the term when I didnt know what I didnt know, which is a particularly pernicious problem. I understood the theory well enough for instance, what a linked list was, how it worked, its various operations and their time complexities, the ADTs (abstract data types) it supported, and how the ADT operations were implemented.But because I didnt know what I didnt know, I couldnt identify gaps in my understanding of its practical applications in problem-solving.The different types of questionsAn example of a data structures question: describe how you would insert a node in a linked list and state the time complexity.And heres an algorithms question: search for an element in a rotated sorted array and state the time complexity.Finally, a problem-solving question, which I consider to be at a higher level than the previous two, might briefly describe a scenario, and list the requirements of the problem. In an exam it might ask for a description of the solution. In competitive programming it might require you to submit working code without explicitly providing any data structures or algorithms. In other words, you are expected to apply the most applicable data structures and algorithms to solve the problem as efficiently as possible.How can you improve your data structures, algorithms, and problem-solving skills?I primarily use three websites for practice: HackerRank, LeetCode, and Kattis. They are largely similar, especially the first two, but not identical. I find that each site has a slightly different focus, each of which is immensely helpful in its own way.I would loosely categorize the skills required for problem-solving into:knowledge of data structuresknowledge of algorithmsknowledge of the application of data structures and algorithmsThe first two could be considered the primitives, or building blocks, that go into the third, which is about knowing what to apply for a particular scenario.Knowledge of data structuresIn this respect, I found HackerRank to be a valuable resource. It has a section dedicated to data structures, which you can filter by type, such as arrays, linked lists, (balanced) trees, heaps, and so forth.The questions are not so much about problem-solving as they are about working with data structures. For instance:You get the idea. Some of the questions might not ever be directly applicable in problem-solving. But they are great for conceptual understanding, which is extremely important in any case.HackerRank does not have freely accessible model solutions, although the discussions section is usually full of hints, clues, and even working code snippets. I have found those to be adequate so far, although you might have to step through the code a line at a time in an IDE to really understand something.Knowledge of algorithmsHackerRank also has an algorithms section, although I prefer LeetCode for this. I found LeetCodes variety of problems to be a lot wider, and I really like that a lot of problems have solutions with explanations and even time complexities.A great starting point would be LeetCodes top 100 liked questions. Some questions which I thought were great:Unlike data structures questions, the focus here isnt so much about working with or manipulating data structures, but rather, how to do something. For instance, the accounts merge problem is primarily on the application of standard UFDS algorithms. The searching in a rotated sorted array problem presents a twist on binary search. And sometimes you learn an entirely new problem-solving technique. For example, the sliding window solution for the longest continuous increasing subsequence problem.Knowledge of the application of data structures and algorithmsFinally, I use Kattis to improve my general problem-solving skills. The Kattis Problem Archive has a bunch of programming problems from various sources, such as competitive programming competitions, around the world.Kattis can be incredibly frustrating because there are no official solutions or a discussion forum, (unlike HackerRank and LeetCode). Also, test cases are private. I have a handful of pending Kattis problems which I cant solve not because I dont know the solution, but because I cant figure out the bug.Its my least favorite site among the three for practicing and learning, and I didnt spend a lot of time on it.Other resourcesGeeksforgeeks is another very valuable resource for learning about data structures and algorithms. I like how it provides code snippets in various languages, usuallyC++, Java, and Python, which you can copy and paste into your IDE to step through line-by-line.Finally, there is trusty old Google, which would lead you to GeeksForGeeks most of the time, and Youtube, for visual explanations.ConclusionAt the end of the day, however, there are no shortcuts. You just have to dive into it head-first start writing code, debugging code, and reading other peoples correct code to figure out where, how, and why you went wrong. Its tough, but you get better with each attempt, and it gets easier as you get better.Im nowhere near the level of competency I want to be, but Ive definitely come a long way since I started. :) CategoryArrayBacktrackingBinary TreeBit ManipulationBSTDivide & ConquerDynamic ProgrammingGraphHeapLinked ListMatrixProgramming PuzzlesQueueSortingStackStringTrie TagAlgorithmBinary SearchBottom-upBreadth-First SearchDepth-First SearchGreedyHashingMust KnowPriority QueueRecursiveSliding WindowTop-down DifficultyEasyMediumHardBeginner Curated ListsTop 100 Most LikedTop 50 ClassicTop 25 AlgorithmsTop 10 DP1. Find a pair with the given sum in an arrayArray, SortingAmazon, HashingTopClassic, TopLikedEasy2. Check if a subarray with 0 sum exists or notArrayHashingTopLikedMedium3. Print all subarrays with 0 sumArrayAmazon, HashingTopLikedMedium4. Sort binary array in linear timeArray, SortingTopLikedEasy5. Find maximum length subarray having a given sumArrayHashingTopLikedMedium6. 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I will dive deep into 20 problem-solving techniques that you must know to excel at your next interview. They have helped me at work too and even given me ideas for a side project I am working on. Also, the last section includes astep-by-step guideexplaining how tolearn data structures and algorithms, with examples.Furthermore, I recommend you readthis post, where I outlined a high-level strategy to prepare for your next coding interview as well as the top mistakes to avoid.I have grouped these techniques in:Pointer basedRecursion basedSorting and searchingExtending basic data structuresMiscellaneaI will explain each of them, show how to apply them to coding problems, and leave you some exercises so that you can practice on your own. For your convenience, I have copied here the problem statements, but I have left links to all of the exercises. You can copy-paste my solution and play around with it. I strongly recommend you code your solution and see if it passes the tests.Some of the questions are better explained through an image or diagram. For these, I have left a comment asking you to open the link to get a graphical description of the problem.This list is part of the study notes that I took before I applied to Amazon. I hope they will be as useful to you as they have been to me.Pointer based techniques1. Two PointersThis technique is very useful onsorted arraysand arrays whose elements we want togroup.The idea is to use two (or more pointers) to split the array into different areas or groups based on some condition:Elements smaller than, equal to and greater than a certain valueElements whose sum is too small or too largeEtc.The following examples will help you understand this principle.Two sumGiven an array of integers that is already sorted in ascending order, find two numbers such that they add up to a specific target number. The function twoSum should return indices of the two numbers such that they add up to the target, where index1 must be less than index2.Notes:Your returned answers (both index1 and index2) are not zero-based.You may assume that each input would have exactly one solution and you may not use the same element twice.Example:Input: numbers = [2,7,11,15], target = 9Output: [1,2]Explanation: The sum of 2 and 7 is 9. Therefore index1 = 1, index2 = 2.SolutionSince the arrayais sorted, we know that:The largest sum is equal to the sum of the last 2 elementsThe smallest sum is equal to the sum of the first 2 elementsFor any indexiin [0, a.size() 1) => a[i + 1] >= a[i]With this, we can design the following algorithm:We keep 2 pointers:l, starting at the first element of the array, andrstarting at to the last.If the sum of a[l] + a[r] is smaller than our target, we increment l by one (to change the smallest operand in the addition for another one equal or larger than it atl+1); if it is larger than the target, we decrease r by one (to change our largest operand for another one equal or smaller atr-1).We do this until a[l] + a[r] equals our target or l and r point to the same element (since we cannot use the same element twice) or have crossed, indicating there is no solution.Here is a simple C++ implementation:vector twoSum(const vector& a, int target) { int l = 0, r = a.size() - 1; vector sol; while(l < r) { const int sum = a[l] + a[r]; if(target == sum) { sol.push_back(l + 1); sol.push_back(r + 1); break; } else if (target > sum) { ++l; } else { --r; } } return sol;}The time complexity is O(N), since we may need to traverse the N elements of the array to find the solution.The space complexity is O(1), since we only need two pointers, regardless of how many elements the array contains.There are other ways of solving this problem (using a hash table, for example), but I have used it just as an illustration of the two pointer technique.ChallengesHere are two variations of this exercise:three sumandfour sum. They can be solved similarly byreducingthem to this very same problem.This is a very common technique:transform a problem whose solution you dont know to a problem that you can solve.Given a sorted array, nums, remove the duplicates in-place such that each element appears only once and return the new length.Do not allocate extra space for another array, you must do this by modifying the input array in-place with O(1) extra memory.Example 1:Given nums = [1,1,2],Output = 2Example 2:Given nums = [0,0,1,1,1,2,2,3,3,4],Output = 5It doesnt matter what values are set beyond the returned length.SolutionThe array issortedand we want to move duplicates to the end of the array, which sounds a lot likegrouping based on some condition. How would you solve this problem using two pointers?You will need one pointer to iterate through the array,i.And a second pointer,n, one to define the area that contains no duplicates: [0,n].The logic is as follows. If the values of the elements at indexi(excepti= 0) andi-1are:The same, we dont do anything this duplicate will be overwritten by the next unique element ina.Different: we adda[i]to the section of the array that contains no duplicates delimited byn, and increment n by one.int removeDuplicates(vector& nums) { if(nums.empty()) return 0; int n = 0; for(int i = 0; i < nums.size(); ++i){ if(i == 0 || nums[i] != nums[i - 1]){ nums[n++] = nums[i]; } } return n;}This problem has linear time complexity and constant space complexity (it is usually the case for problems solved using this technique).Sort colorsGiven an array with n objects colored red, white, or blue, sort them in-place so that objects of the same color are adjacent, with the colors in the order red, white, and blue. Here, we will use the integers 0, 1, and 2 to represent the color red, white, and blue respectively.Note: You are not supposed to use the librarys sort function for this problem.Example:Input: [2,0,2,1,1,0]Output: [0,0,1,1,2,2]SolutionThe groups this time are:Smaller than 1Equal to 1Larger than 1What we can achieve with 3 pointers.This implementation is a bit tricky, so make sure you test it thoroughly.void sortColors(vector& nums) { int smaller = 0, eq = 0, larger = nums.size() - 1; while(eq next != nullptr) { slow = slow->next; fast = fast->next->next; } return slow; }Given a linked list, determine if it has a cycle in it. To represent a cycle in the given linked list, we use an integer pos which represents the position (0-indexed) in the linked list where the tail connects to. If pos is -1, then there is no cycle in the linked list.Example 1:Input: head = [3,2,0,-4], pos = 1Output: trueExplanation: There is a cycle in the linked list, where the tail connects to the second node.SolutionThe simplest solution is to add all the nodes to a hash set. When we traverse the list, if we get to a node that has already been added to the set, there is a cycle. If we get to the end of the list, there are no cycles.This has a time complexity of O(L), beingLthe length of the list, and space complexity of O(L), since in theworstcase no cycles we need to add all the elements of the list to the hash set.Time complexity cannot be improved. However, space complexity can be reduced to O(1). Think for a minute how this can be achieved with two pointers moving at different speeds.Lets call these pointers fast and slow. For each node slow visits, fast will move two nodes forward. Why?If fast reaches the end of the list, the list does not contain any cycles.If there is a cycle, since fast moves twice as fast as slow, it is just a matter of time (iterations, to be more precise) that the fast node catches the slow one, pointing both to the same node, which indicates the existence of a cycle.Now, lets translate this solution into code:bool hasCycle(ListNode *head) { ListNode* slow = head, *fast = head; while(fast){ slow = slow->next; fast = fast->next; if(!fast) break; fast = fast->next; if(slow == fast) return true; } return false;}Find the duplicate numberGiven an array, nums, containing n + 1 integers where each integer is between 1 and n (inclusive), prove that at least one duplicate number must exist. Assume that there is only one duplicate number, find the duplicate one.Example 1:Input: [1,3,4,2,2]Output: 2SolutionThis is the same problem/solution as the previous problems, for arrays instead of linked lists.int findDuplicate(const vector& nums) { int slow = nums[0], fast = slow; do { slow = nums[slow]; fast = nums[nums[fast]]; } while(slow != fast); slow = nums[0]; while(slow != fast){ slow = nums[slow]; fast = nums[fast]; } return slow;}ChallengesHere are more problems that can be solved using this technique:Detect if two linked lists have elements in commonHappy numbers3. Sliding WindowThe sliding window technique eases the task of finding optimalchunks of contiguous datathat meet a certain condition:Longest subarray that Shortest substring containing EtcYou can think of it as another variation of the two pointer technique, where pointers are updated separately based on a certain condition. Below is the basic recipe for this type of problems, in pseudocode:Create two pointers, l, and rCreate variable to keep track of the result (res) Iterate until condition A is satisfied: Based on condition B:update l, r or bothUpdate resReturn resGiven a string, find the length of the longest substring without repeating characters.Example 1:Input: abcabcbbOutput: 3Explanation: The answer is abc, with the length of 3SolutionFind the length of the longest substring without repeating characters sounds a lot likefinding optimal *chunks of contiguous datathat meet a certain condition.*Based on the recipe I described above, you will need:Two pointers,landr, to define our substrings.A variable,sol, to store the length of the longest substring we have seen so far.A way of keeping track of the characters that forms: a set,seen, will be perfect for this.While iterating through the string:If the current character is inseen*you have to increment *lto start removing elements from the beginning of ours.Otherwise, add the character toseen, moverforward and updatesol.int lengthOfLongestSubstring(const string& s) { int sol = 0; int l = 0, r = 0; unordered_set seen; while(r < s.size()) { const auto find = seen.find(s[r]); if(find == seen.end()) { sol = max (sol, r - l + 1); seen.insert(s[r]); ++r; } else { seen.erase(s[l++]); } } return sol;}ChallengesFor more practice, you can try the following problems:Permutation of a stringMax consecutive onesThere might be simpler solutions but focus on using this technique to get a better grasp of it.Recursion based techniques4. Dynamic ProgrammingI already published a long and detailed article on this topic that you can findhere.5. BacktrackingThe idea behind backtracking is to explore all the potential solutions for a problem, in a smart way. It builds candidate solutions incrementally and as soon as it determines that a candidate solution is not viable, itbacktracks to a previous state and tries the next candidate.Backtracking problems present you with a list of choices. Should you:Placethis pieceinthis position?Addthis numberto the set?Trythis numberinthis positionnext?EtcAfter you have picked one of the options, it will get you a new list of choices, until you reach a state where there are no more choices: either you arrived at a solution or there is no solution.Visually, you are moving from the root of a tree with every choice, until you get to a leaf. The basic high-level recipe (in pseudocode) for a backtracking algorithm is the following:boolean backtracking(Node n){ if(isLeaf(n) { if(isSolution(candidate)){ sol.add(candidate); return true; } else { return false; } } //Explore all children for(child in n) { if(backtracking(child)) return true; } return false;}This can of course change depending on the problem:If you needallsolutions, the helper function returns nothing (void) to avoid stopping when we find the first solution.To backtrack, you may have to bring your program to a previous state before you can move forwardAfter you choose a child, you need to detect if the candidate solution is viable or not: the definition of viable depends on the problemEtcBut the core idea is the same: examine, in a systematic way, all paths and backtrack as soon as the current path is no longer viable.N queensThe n-queens puzzle is the problem of placing n queens on an nn chessboard such that no two queens attack each other Given an integer n, return all distinct solutions to the n-queens puzzle.Each solution contains a distinct board configuration of the n-queens placement, where Q and . both indicate a queen and an empty space respectively.Example:Input: 4Output: [[.Q.., Q, Q, ..Q.], [..Q., Q, Q, .Q..]]Explanation: There exist two distinct solutions to the 4-queens puzzle as shown above.SolutionThis is a classic backtracking problem:We need all solutions here, which is why the recursive function returns nothing as I explained in the introduction of this section.Do not worry too much about theisViableSolutionfunction for now. Try to see the recipe I gave (slightly modified) you in action.class Solution {public: vector solveNQueens(int n) { vector solutions; /** This is usually solved with a vector of integers, where each integer represents the position of the queen in that column. This particular problem expects strings. Each string represents a column */ vector board(n, string(n, '.')); solveBoard(solutions, board, 0, n); return solutions; } void solveBoard(vector& solutions, vector& board, int col, int n){ if(col == n){ solutions.push_back(board); return; } for(int row = 0; row < n; row++){ if(isViableSolution(board, row, col)){ board[row][col] = 'Q'; solveBoard(solutions, board, col + 1, n); //Backtracking - we bring our board to the previous state board[row][col] = '.'; } } } bool isViableSolution(vector& board, int row, int col){ int n = board.size(); for(int x = 1; x = 0 && col >= x; x++){ if(board[row-x][col-x] == 'Q') return false; } for(int x = 1; row + x < n && col >= x; x++){ if(board[row+x][col-x] == 'Q') return false; } return true; }};Letter combinationGiven a string containing digits from 2-9 inclusive, return all possible letter combinations that the number could represent (check the link for diagram). Note that 1 does not map to any letters.Example:Input: 23Output: [ad, ae, af, bd, be, bf, cd, ce, cf].SolutionFor every number in the input, you have several letters to choose from. If you can draw a tree (this is what I do) where the branches are born from the different choices you take, chances are that you can apply backtracking.Note: Before you start solving any problem, try different approaches: dynamic programming, greedy algorithms, divide and conquer, a combination of algorithms and data structures, etc. Coding is thelast step.My solution, in C++:vector letterCombinations(const string &digits) { if(digits.empty()) return {}; const vector letters {"", "", "abc", "def", "ghi", "jkl", "mno", "pqrs", "tuv", "wxyz"}; vector sol; string candidate (digits.size(), ' '); h(sol, 0, candidate, letters, digits); return sol;} void h(vector &sol, int idx, string &candidate, const vector &letters, const string &digits){ if(idx == digits.size()){ sol.push_back(candidate); return; } for(const char &c : letters[digits[idx] - '0']) { candidate[idx] = c; h(sol, idx + 1, candidate, letters, digits); }}Since I knew already the size of the solution, I initialize mycandidatewith that size and just modified the character at positionidx. If the size is not known, this can be done instead:string candidate; //instead of string candidate (digits.size(), ' ');for(const char &c : letters[digits[idx] - '0']) { candidate.push_back(c); h(sol, idx + 1, candidate, letters, digits); candidate.pop_back();} Sudoku solverWrite a program to solve a Sudoku puzzle by filling the empty cells. Open the link to get a longer description, including an image of the puzzle.SolutionIn an interview, unless you have plenty of time, you will not need to implementisViableSolution, just to sketch it. I know a colleague who got this question in an on-site.Even though the code is long, it is mostly because ofisViableSolution. Otherwise, it is not very different from other backtracking problems.void solveSudoku(vector& board){ helper(board);} bool helper(vector& board, int row = 0, int col = 0) { if(col == size){ col = 0; ++row; if(row == size){ return true; } } if(board[row][col] != '.'){ return helper(board, row, col + 1); } for(char i = '1'; i nums2[j]) { ++j; } else { ++i; } } return sol;}The time complexity of this approach is O(n log n) even though the two-pointer part is linear and the space complexity is O(1) not including the space needed to store the intersection, of course, in which case we could say it is O(min(length(A), length(B)).Challenges8. IntervalsMost interval related problems I have seen boil down to:Modeling the intervalas an array of two elements, a pair/tuple or a custom class (this is the cleanest option)Sortingthe inputIterating through the sorted array and deciding what to do based on the starts/ends of the intervalsYou can see this as yet another type of problem that can be simplified after sorting the input, which is why I have included it in this section.Im leaving here my solution to two exercises, based on what I have just described. Try them before reading my solutions.Merge intervalsGiven a collection of intervals, merge all overlapping intervals.Example 1:Input: intervals = [[1,3],[2,6],[8,10],[15,18]]Output: [[1,6],[8,10],[15,18]]Explanation: Since intervals [1,3] and [2,6] overlaps, merge them into [1,6].Solutionvector merge(vector& intervals) { sort(intervals.begin(), intervals.end(), [](const auto& i1, const auto& i2){ return i1[0] < i2[0]; }); int i = 0; vector sol; vector curr(2); while(i < intervals.size()){ curr = intervals[i++]; while(i < intervals.size() && intervals[i][0] x >= 4, which is true for any integer in the range [2,]With this, we can search in [2, x/2] and speed things up a bit.int mySqrt(int x) { if(x == 0 || x == 1) return x; int sol = 1; int l = 2, r = x / 2; while(l x){ r = m - 1; } else { sol = m; l = m + 1; } } return sol;}ChallengesHave fun!10.Breadth-First SearchThis is one of the techniques you need to know to explore trees and graphs. Since many problems can be modeled as graphs, youmust know this technique. To implement it, we just need to use a queueqand add to this same queue the children of the nodes we process fromq.At any given point in the iteration, BFS visits all the nodes at the same distance from the origin. This will become clearer after some of these examples.Word ladderGiven two words (beginWord and endWord), and a dictionarys word list, find the length of the shortest transformation sequence from beginWord to endWord, such that:Only one letter can be changed at a time.Each transformed word must exist in the word list.Notes:Return 0 if there is no such transformation sequence.All words have the same length.All words contain only lowercase alphabetic characters.You may assume no duplicates in the word list.You may assume beginWord and endWord are non-empty and are not the same.Example 1:Input:beginWord = hit,endWord = cog,wordList = [hot,dot,dog,lot,log,cog]Output: 5Explanation: As one shortest transformation is hit -> hot -> dot -> dog -> cog, return its length 5.SolutionI got asked this question during my on-site interview at Amazon. The idea is to model this problem using a graph:Nodes represent wordsEdges connect words that only differ by one letterWith this setup, this problem is equivalent to finding a path between two nodes in a graph, which BFS can solve. Since all edges have the same weight (1), we do not need Dijkstra or any other fancier algorithm.int ladderLength(const string &beginWord, const string &endWord, const vector& wordList) { if(beginWord == endWord) return 1; unordered_set dict(wordList.begin(), wordList.end()); queue todo; todo.push(beginWord); dict.erase(beginWord); int ladder = 1; while (!todo.empty()) { ladder++; int n = todo.size(); for (int i = 0; i < n; i++) { string word = todo.front(); todo.pop(); for (int j = 0; j < word.size(); j++) { char c = word[j]; for (int k = 0; k < 26; k++) { word[j] = 'a' + k; if (dict.find(word) != dict.end()) { if (word == endWord) { return ladder; } todo.push(word); dict.erase(word); } } word[j] = c; } } } return 0;}After you visit the DFS section:What would happen if we use DFS instead? Do you see any benefits/drawbacks?Order level tree traversalGiven a binary tree, return the level order traversal of its nodes values. (ie, from left to right, level by level).Open the link for a graphical description of the problem.SolutionYou only need to add here a little tweak to the standard BFS algorithm: you need to know how many elements in the queue you need to process for each level.This is one approach that can be applied to many other problems.vector levelOrder(TreeNode* root) { if(!root) return {}; vector sol; queue q; q.push(root); vector partial; while(!q.empty()){ int size = q.size(); while(size-->0){ auto n = q.front(); partial.push_back({n->val}); q.pop(); if(n->left) q.push({n->left}); if(n->right) q.push({n->right}); } sol.push_back(partial); partial.clear(); } return sol;}ChallengesLet me propose a different kind of challenge: building something, instead of solving abstract problems. I find it more fun and you can add them to your Github profile. Here are just two examples:Web crawlerusing BFS to explore all the links on a website.Minesweeper11.Depth-First SearchSimilar to BFS in its purpose: explore trees and graphs. DFS is not guaranteed to find the shortest path between two points, but it will find any existing path.It is usually shorter to implement than BFS. Some people find it easier. Others, because of the recursive calls, not so much. It is up to you. Just make sure you think about potential stack overflow issues if the size of the stack starts to get big.Some problems are much easier to be solved with DFS/recursion, that it is worth practicing.Number of islandsGiven a 2d grid map of 1s (land) and 0s (water), count the number of islands. An island is surrounded by water and is formed by connecting adjacent lands horizontally or vertically. You may assume all four edges of the grid are all surrounded by water.Example:Input: grid = [[1,1,1,1,0], [1,1,0,1,0], [1,1,0,0,0], [0,0,0,0,0]]Output: 1SolutionI got this problem at my first phone interview at Amazon.As soon as you see a matrix, think of a graph. This problem (and its variations) is very straightforward:Iterate through the matrixFor every 1 you find, increase the counter and sink the islandTo sink the island, you need to visit all the surrounding 1s in the matrix, which is equivalent tovisit all the neighbors of that node and of all its neighbors, which sounds a lot like a recursive problem.You can try to solve this using BFS too, but DFS is much shorter.int numIslands(vector& grid) { int numIslands = 0; for(int r = 0; r < grid.size(); ++r){ for(int c = 0; c < grid[0].size(); ++c){ if(grid[r][c] == '1'){ ++numIslands; sinkIslands(grid, r, c); } } } return numIslands;} const vector dirs {{1, 0}, {-1, 0}, {0, 1}, {0, -1}}; void sinkIslands(vector &m, int r, int c){ m[r][c] = '0'; for(const auto &d : dirs){ const int nr = r + d[0]; const int nc = c + d[1]; if(isValid(m, nr, nc)){ sinkIslands(m, nr, nc); } }} bool isValid(vector &m, int r, int c){ return r >= 0 && r < m.size() && c >= 0 && c < m[0].size() && m[r][c] == '1';}Symmetric treeGiven a binary tree, check whether it is a mirror of itself (ie, symmetric around its center).SolutionMany tree-related problems have relatively straightforward recursive solutions. This problem could be solved using BFS but DFS makes it so much easier.I will leave this one here as an exercise for you. Just use my solution in case you get stuck.bool isSymmetric(TreeNode* root) { if(!root) return true; return helper(root->left, root->right);} bool helper(TreeNode* p, TreeNode* q){ if(!p && !q) return true; if(!p || !q) return false; return p->val == q->val && iS(p->left, q->right) && iS(p->right, q->left);}ChallengesTake the same challenges and exercises I gave you for BFS and try to implement them using DFS instead. Also, for more practice, give a try to the following exercises:Path sumPath sum 2Validate BST12.Topological sortYou can see this algorithm as an application of DFS. Its implementation just needs one minor change to the regular DFS: after processing all the children of a node, add this node to a stack.It is that simple.The best way to intuitively understand what this algorithm achieves is to imagine a bunch of tasks, some of which depend on others (task 1 cannot start until task 2 has finished). A topological sort will list all these tasks preserving this structure of dependencies.Lets solve a problem using this algorithm.Course schedule IIThere are a total of n courses you have to take, labeled from 0 to n-1. Some courses may have prerequisites, for example, to take course 0 you have to first take course 1, which is expressed as a pair: [0,1]Given the total number of courses and a list of prerequisite pairs, return the ordering of courses you should take to finish all courses. There may be multiple correct orders, you just need to return one of them. If it is impossible to finish all courses, return an empty array.Example 1:Input: 2, [[1,0]]Output: [0,1]Explanation: There are a total of 2 courses to take. To take course 1 you should have finished course 0. So the correct course order is [0,1].Example 2:Input: 4, [[1,0],[2,0],[3,1],[3,2]]Output: [0,1,2,3] or [0,2,1,3]Explanation: There are a total of 4 courses to take. To take course 3 you should have finished both courses 1 and 2. Both courses 1 and 2 should be taken after you finished course 0. So one correct course order is [0,1,2,3]. Another correct ordering is [0,2,1,3].SolutionThis is the classical topological sort problem. We have a bunch of courses to take and some depend on others. This can be modeled as a directed graph. A topological sort would returnthe ordering of courses you should take to finish all courses. A prerequisite to applying topological sort is that the graph isdirected and acyclic. From the problem description, we can see that the graph is directed. We can detect if it contains any cyclesandcompute a topological sort in the same pass. A more indirect but still valid approach would be to first check whether it has cycles and only if there are no cycles, compute a topological sort.vector findOrder(int numCourses, vector& prerequisites) { vector adj(numCourses, vector(0)); for(const auto &p : prerequisites) { int u = p[0]; int v = p[1]; adj[u].push_back(v); } vector white(numCourses, true), grey(numCourses), black(numCourses); vector sol (0); for(int i = 0; i < numCourses; ++i) { if(white[i] && hasCycle(adj, i, white, grey, black, sol)) { return {}; } } return sol;} bool hasCycle(const vector& adj, int i, vector &white, vector &grey, vector &black, vector& sol) { //We have started exploring this node white[i] = false; grey[i] = true; for(const auto & n : adj[i]){ if(black[n]) continue; if(grey[n] || hasCycle(adj, n, white, grey, black, sol)) return true; } grey[i] = false; black[i] = true; sol.push_back(i); return false;}ChallengesHereyou can find a few more problems to practice.Have fun!Extending basic data structures13. Dequeuest have seen data structure mostly used as another way to implement the sliding window technique you read about earlier in this article. The only difference with a standard FIFO queue is that you can operate (insert and delete elements) onboth endsof the queue.Thats it. Simple.Lets see how such a minor change can simplify some kind of these problems.Sliding window maximumGiven an array, nums, there is a sliding window of size k which is moving from the very left of the array to the very right. You can only see the k numbers in the window. Each time the sliding window moves right by one position. Return the max sliding window.Note: Open the link for a better understanding of the problem (there is an image).Example:Input: nums = [1,3,-1,-3,5,3,6,7], and k = 3Output: [3,3,5,5,6,7]SolutionWe will use the dequeue to storeindices, not values. We need this to know what elements are still part of the sliding window. For every iteration, there are four things to do.Remove elements in the dequeue which are outside of the current sliding window (one per iteration)Remove allelements in the dequeue which are smaller than the current element we are at since they cannot represent the max of that sliding windowAdd the current element to the dequeueOnce we have completed the first sliding window, we can start adding elements to our solution. By design, the element at the front of our dequeue will contain the maximum of the sliding window, which is what we are interested in.This technique can be applied to find the minimum or other properties of a contiguous block of data in an array.vector maxSlidingWindow(const vector& nums, int k) { vector sol; deque dq; for (int i=0; i= k-1) sol.push_back(nums[dq.front()]); } return sol;}ChallengeDesign your owncircular dequeue, to fully grasp the internals of this data structure.14.TrieThe best way to think of a trie is as an extension of a tree, where you store characters that form words as you move through the different branches of the trie.There are variants where you store suffixes instead of prefixes, where you use compression to reduce the size of the trie, etc. But at its basic, it is another type of tree.They are used everywhere:Auto-completeSpell checkersIP routingLongest prefix/suffix matchingEtcImplement a trieImplement a trie with insert, search, and startsWith methods.SolutionHere is a simple implementation (for an interview, of course) of a trie. Compared to a tree, you just:An extra boolean to indicate whether that node marks the end of a wordA data structure to store pointers to the nodes children: a hash table, an array of characters, etc.class Trie{ private: struct Node{ bool isWord; unordered_map children; Node() : isWord(false) {} }; Node* findNode(const string &word){ Node* curr = root; for(int i = 0; i < word.size() && curr; ++i) curr = curr->children[word[i] - 'a']; return curr; } public: Node* root; /** Initialize your data structure here. */ Trie() { root = new Node(); } /** Inserts a word into the trie. */ void insert(const string &word) { Node * curr = root; for(int i = 0; i < word.size(); ++i){ const char c = word[i] - 'a'; if(!curr->children[c]){ Node* newNode = new Node(); curr->children[c] = newNode; } curr = curr->children[c]; } curr->isWord = true; } /** Returns true if the word is in the trie. */ bool search(const string &word) { Node * curr = findNode(word); return curr ? curr->isWord : false; } /** Returns true if there is any word in the trie that starts with the given prefix. */ bool startsWith(const string &prefix) { Node * curr = findNode(prefix); return curr ? true : false; } };Word search IIGiven a 2D board and a list of words from the dictionary, find all words in the board. Each word must be constructed from letters of sequentially adjacent cells, where adjacent cells are those horizontally or vertically neighboring. The same letter cell may not be used more than once in a word.Example:Input: board = [[o,a,a,n], [e,t,a,e], [i,h,k,r], [i,f,l,v]] words = [oath,pea,eat,rain]Output: [eat,oath]SolutionThis might not be the simplest way of solving this problem, but it is a clear application of a trie.At every step, you will have built some candidate string and need to check if it belongs to the dictionary. A hash set containing all the words in the dictionary would give a very good performance. Why bothering with a trie then? Because a trie can tell you whether that path is worth exploring or not, improving the efficiency of our solution.In our previous example, imagine we form the string oa.We can check if this prefix (potential word) exists in our trie. It exists since we have added the word oath. Now imagine we keep moving right through our board and form the string oaa. In our trie, there are no words that contain the prefix oaa, so we can backtrackat this point.With a hash set that contains all the words, you could not do this type of prefix matching, unless you create two different tables: one for prefixes and another one for words.This is a complex problem because it combines different elements and it is not easy to implement, so do not get discouraged if it takes you a few tries (no pun intended) to get it right.const vector dirs {{1, 0}, {-1, 0}, {0, 1}, {0, -1}};struct Trie{ struct Node{ bool isWord; unordered_map children; Node() : isWord(false){} }; Node* root; Trie(){root = new Node();} void insert(const string& w){ Node* curr = root; for(const auto &c : w){ if(curr->children.find(c) == curr->children.end()){curr->children[c] = new Node();} curr = curr->children[c]; } curr->isWord = true; } bool hasPrefix(const string &prefix){ Node* curr = root; for(const auto &c : prefix) { if(curr->children.find(c) == curr->children.end()) return false; curr = curr->children[c]; } lastNode = curr; return true; } bool isValidWord(const string& w){ bool res = lastNode->isWord; lastNode->isWord = false; return res; } void deleteWord(){ lastNode->isWord = false; lastNode = nullptr; } Node* lastNode;}; Trie t;public:vector findWords(vector& board, vector& words) { for(const auto& w : words) t.insert(w); vector sol; for(int row = 0; row < board.size(); ++row){ for(int col = 0; col < board[0].size(); ++col){ helper(board, row, col, sol, candidate); } } return sol; } void addWords(vector &board, int row, int col, vector& sol, string &candidate){ if(t.isValidWord(candidate)){ sol.push_back(candidate); t.deleteWord(); } const char old = board[row][col]; board[row][col] = '-'; for(const auto &d : dirs){ const int nrow = row + d[0]; const int ncol = col + d[1]; if(nrow >= 0 && nrow < board.size() && ncol >= 0 && ncol < board[0].size() && board[nrow][ncol] != '-' && t.hasPrefix(candidate + board[nrow][ncol])){ candidate.push_back(board[nrow][ncol]);addWords(board, nrow, ncol, sol, candidate);candidate.pop_back(); } } board[row][col] = old; }};ChallengesDesign your ownautocomplete system!15. Two instances of the same data structureSome problems can be solved by using two different instances of the same data structure, so it is worth keeping it in mind when you get stuck in a problem.I will group most of them in this section. Median of Data StreamMedian is the middle value in an ordered integer list. If the size of the list is even, there is no middle value. So the median is the mean of the two middle values.For example,[2,3,4], the median is 3[2,3], the median is (2 + 3) / 2 = 2.5Design a data structure that supports the following two operations:void addNum(int num) Add an integer number from the data stream to the data structure.double findMedian() Return the median of all elements so far.Solutionclass MedianFinder { priority_queue L; priority_queue H; public: MedianFinder() { } void addNum(int x) { if(L.empty() == false && x > L.top()) { H.emplace(x); } else { L.emplace(x); } if(H.size() > L.size() + 1) { L.emplace(H.top()); H.pop(); } else if(L.size() > H.size() + 1) { H.emplace(L.top()); L.pop(); } } double findMedian() { if(H.size() == L.size()) { return (H.top() + L.top()) * 0.5; } else { return H.size() > L.size() ? H.top() : L.top(); } }};ChallengesIn increasing order of difficulty:Miscellanea16. Bit manipulationThis section deserves a separate article. Here I will list some basictricks and common bit manipulation problems.This isthe most comprehensive siteI have found on this topic. Use it as a reference.Missing numberGiven an array containing n distinct numbers taken from 0, 1, 2, ..., n, find the one that is missing from the array.Example 1:SolutionThis problem can be solved just by using the XOR operator:Any bit XORed with itself produces a 0 -> a ^ a = 0Any bit XORed with 0 produces the original bit -> a ^ 0 = aXOR is associative = a ^ (b ^ c) = (a ^ b) ^ cIf we XOR all the numbers in the array (integers in the range [0,n]) with all the integers in [0 to n], the pairs will producezeroesand the missing number will be XORed with 0 (resulting in itself), solving our problem.int missingNumber(const vector& nums) { int res = nums.size(); for(int i = 0; i < nums.size(); ++i) res ^= (i ^ nums[i]); return res; }Power of twoGiven an integer, write a function to determine if it is a power of two.SolutionI got this one in an interview.Powers of two can be expressed in binary as a leading 1 and a set of 0s:With this, it is simple to figure out if a number is a power of two or not. You can achieve fast if you know what the following line does (I am sure you can figure it out on your own):This trick is worth knowing since it is used a lot.bool isPowerOfTwo(int n) { return n > 0 ? (n & (n - 1)) == 0 : false; }Number of 1sWrite a function that takes an unsigned integer and returns the number of 1 bits it has (also known as the Hamming weight).Example 1:Input: 00000000000000000000000000001011Output: 3Explanation: The input binary string 00000000000000000000000000001011 has a total of three 1 bits.SolutionThis problem is very straightforward: iterate through all the bits in the input and count how many of them are 1s.Try to use the trick I showed you in the previous exercise to improve the performance of this algorithm (in the average case).int hammingWeight(uint32_t n) { int sum = 0; while (n != 0) { sum++; n &= (n - 1); } return sum; }ChallengesThese are for you to practice the previous techniques:Single numberGray codeHamming distancePower of 417. Top K ElementsThis is another very frequent type of problem. You are given a list of elements and have to return the top K, definingtopas:The largest/smallestThe closest/furthest to a pointThe most frequent in the listEtcI have seen some of the following (or some sort of variation) asked in interviews.There is no single data structure that will always give the right solution, but the following elements are very useful:Hash tablePriority queueSorting (the input or as an intermediate step)Priority queues usually provide a better complexity.Top k frequent wordsGiven a non-empty list of words, return the k most frequent elements. Your answer should be sorted by frequency from highest to lowest. If two words have the same frequency, then the word with the lower alphabetical order comes first.Example 1:Input: [i, love, leetcode, i, love, coding], k = 2Output: [i, love]Explanation: i and love are the two most frequent words. Note that i comes before love due to a lower alphabetical order.SolutionPretty straightforward: count how many times each word appears (using a hash table) andsomehowreturn the k most common elements.For this last part, you either:Put all the elements with its frequencies in an array and sort itOr use a priority queueIt is worth knowing this second approach since it can be applied to other problems.Here is a simple solution in C++ using a priority queue.vector topKFrequent(const vector& words, int k) { map freq; for(const auto &w : words) freq[w]++; auto l = [](const pair &p1, const pair &p2){ if(p1.first == p2.first) return p1.second < p2.second; else return p1.first > p2.first; }; priority_queue pq(l); for(auto it = freq.begin(); it != freq.end(); ++it){ if(pq.size() < k){ pq.push({it->second, it->first}); } else if(l({it->second, it->first}, pq.top())){ pq.pop(); pq.push({it->second, it->first}); } } vector sol (k); while(!pq.empty()){ sol[--k] = pq.top().second; pq.pop(); } return sol; }VariationK closest points to the originWe have a list of points on the plane. Find the K closest points to the origin (0, 0). Here, the distance between two points on a plane is the Euclidean distance.You may return the answer in any order. The answer is guaranteed to be unique (except for the order that it is in.)Example 1:Input: points = [[1,3],[-2,2]], K = 1Output: [[-2,2]]SolutionThe obvious solution is to compute the distance to every single point, add them to an array, sort and get the top k. This is fine, but it can be improved with a priority queue.We use amax heap, where the root of the heap is the furthest point. For every point, we compute the distance from the origin and the root points to the point that is the furthest from the origin amongst all the other points. If we find a point closer to this one, it may still be further than the rest, but we need to drop our current top and add this new point to the heap.typedef pair pivi;public:vector kClosest(const vector& points, int K) { auto l = [] (const pivi& p1, const pivi &p2) { return p1.first < p2.first; }; priority_queue pq(l); for(const auto &p : points){ //Avoid taking the square root. Won't change the result and it's faster const int d = p[0] * p[0] + p[1] * p[1]; if(pq.size() < K) pq.push({d, {p[0], p[1]}}); else if(pq.top().first > d){ pq.pop(); pq.push({d, {p[0], p[1]}}); } } vector sol; while(!pq.empty()){ sol.push_back({pq.top().second.first, pq.top().second.second}); pq.pop(); } return sol; }18. K-way mergeMerge two sorted listsMerge two sorted linked lists and return it as a new list. The new list should be made by splicing together the nodes of the first two lists.Example:Input: 1->2->4, 1->3->4Output: 1->1->2->3->4->4SolutionWe can solve this problem with the same Two pointer technique we saw at the beginning of this article. In this case, we traverse linked lists instead of arrays, but the same ideas apply.ListNode* mergeTwoLists(ListNode* l1, ListNode* l2) { ListNode dh(1), *curr = &dh; while(l1 && l2){ if(l1->val val) { curr->next = l1; l1 = l1->next; } else { curr->next = l2; l2 = l2->next; } curr = curr->next; } if(l1){ curr->next = l1; } else if(l2) { curr->next = l2; } return dh.next; }Merge k sorted listsGiven an array of linked-lists lists, each linked list is sorted in ascending order.Merge all the linked-lists into one sort linked-list and return it.Example 1:Input: lists = [[1,4,5],[1,3,4],[2,6]]Output: [1,1,2,3,4,4,5,6]Explanation: The linked-lists are:[1->4->5, 1->3->4, 2->6]merging them into one sorted list:1->1->2->3->4->4->5->6SolutionThis is the general version of the previous problem. As I said, you can reduce this problem to many instances of the previous problem by merging lists 2 at a time. However, here I will present a more efficient solution.Now, instead of two sorted lists, we have k. We need to create a list from picking the next minimum element of all the lists. Since they are sorted, it will be the first element of one of these lists. Luckily, there is a data structure that returns its minimum element in O(1) and has an insertion complexity of O(log K): a priority queue.For every list, we add to the priority queue a pair containing:The head of that listAn index to remember to which list that element belongsAfter we pop an element, we add its value to our solution and add to the priority queue the new head of that list (the pair stores the value and the index of the list).With this information, try to solve the problem. You will learn much more from it than from reading my solution without trying first.ListNode* mergeKLists(vector& lists) { typedef pair pni; auto comp = [](const pni& p1, const pni& p2) { return p1.first->val > p2.first->val; }; priority_queue pq (comp); for(int i = 0; i < lists.size(); ++i){ if(lists[i]){ pq.push({lists[i], i}); lists[i] = lists[i]->next; } } ListNode dh(-1), *curr = &dh; while(!pq.empty()){ const auto p = pq.top(); pq.pop(); curr->next = p.first; curr = curr->next; ListNode* next = lists[p.second]; if(next){ int idx = p.second; pq.push({next, idx}); lists[p.second] = lists[p.second]->next; } } return dh.next; }19.Rolling hashRabin Karpis a great example of how to design a simple and efficient algorithm using intelligently a rolling hash function. It can be used to find a stringsin a textt.The basic ideas that you need to remember to be able to reconstruct this algorithm are the following:This is an improvement over the brute force method, where you comparesand every candidate substring,c, which is inefficient.If two strings are the same, they will produce the same hash.The inverse is not true: two different strings may produce the same hash.Using a rolling hash function we can compute the hash of a new string in O(1)If we put all this together, we will efficiently compute hashes and only comparecandswhen they have the same hash, reducing the number of comparisons and thus the average complexity of our algorithm (worst case, we need to compare all substrings and are back to the brute force method).Find string in textReturn the index of the first occurrence of needle in a haystack, or -1 if needle is not part of the haystack.Example 1:Input: haystack = hello, needle = llOutput: 2Example 2:Input: haystack = aaaaa, needle = bbaOutput: -1SolutionBased on the above paragraphs, try to code the Rabin-Karp algorithm on your own to solve this problem.int strStr(const string& haystack, const string& needle) { int nsize = needle.size(); if(nsize == 0) return 0; int hsize = haystack.size(); if(nsize > hsize) return -1; int msbPower = 1; int nhash = 0; int hhash = 0; const int mod = 10000009; //A big prime number for(int i = 0; i lps[j - 1] if p[i] == p[j]: j += 1 lps[i] = j return lps lps = build_lps(pattern) i = j = 0 while i < len(text): if text[i] == pattern[j]: i += 1 j += 1 if j == len(pattern): return i - j else: if j != 0: j = lps[j-1] else: i += 1 return -1 Time Complexity: O(n + m) 19. Floyd's Cycle Detection When to Use: Detect cycles in linked lists. Example: Fast/slow pointers. def has_cycle(head): slow = fast = head while fast and fast.next: slow = slow.next fast = fast.next.next if slow == fast: return True return False Time Complexity: O(n) 20. Meet-in-the-Middle When to Use: Split large problems into halves (e.g., subset sum). Example: Subset sum for large `n`. def subset_sum(arr, target): def generate_subsets(arr): subsets = [] n = len(arr) for mask in range(1