DS & Sys Design

379. Design Phone Directory

Design a Phone Directory which supports the following operations:

get: Provide a number which is not assigned to anyone.

check: Check if a number is available or not.

release: Recycle or release a number.

$Stack\langle int\rangle\ released$

$boolean[]\ used$

$int\ index(index \in [o, maxnumber - 1])$

$get()$:

    $if\,(!\,released.isEmpty())$:

        $phone \cdot number = released.pop()$

        $used[phone \cdot number] = used[phone \cdot number] + 1$

        $return\ phone \cdot number$

    $else$:

        $if\,(index < maxnumber)$:

            $used[index] = true$

            $index = index + 1$

            $return\ index - 1$

        $else: return - 1$

$release(int\ phone \cdot number)$:

    $if\,(used[phone \cdot number])$: $release.add(phone \cdot number)$

    $used[phone \cdot number] = false$

$check(int\ phone \cdot number): return\ !\,used[phone \cdot number]$

---

355. Design Twitter

$map\langle Integer, Set\langle Integer\rangle\rangle\ fans$

$map\langle Integer, Tweet\rangle\ tweets$

$Tweet\begin{cases} tweet_{id} \\ timestamp \\ next \end{cases}$

quite simialr to merge k sorted list(in this case, sorted by timestamp)

$friendlist \leftarrow fans[user_{id}]$

$result \leftarrow new\ list\langle Tweet\rangle$

$for(friend\ f\ :\ friendlist)$:

$Tweet\ tw \leftarrow tweets[friend_{id}].peekFirst()$

$if(tw\ is\ not\ nil)$: $pq.offer(tw)$

$count \leftarrow 0$

$while(!pq.empty\ \&\ count < 10)$:

$Tweet\ top = pq.poll()$

$result.add(top)$

$if(top.next \neq null)$: $pq.offer(top.next)$

$count \leftarrow count + 1$

---

146. LRU Cache

$$\mathcal{N}ode\begin{cases} key \\ val \\ prev \\ next \end{cases} \rightarrow dll\begin{cases} head \\ tail \end{cases}$$

$int\ get(\mathcal{K})$:

$if(keyNode[\mathcal{K}] \neq nil)$:

$node := keyNode[\mathcal{K}]$

$\mathcal{V} := node.val$

$dll.unlink(node)$

$dll.addHead(node)$

$return\ \mathcal{V}$

$return -1$

$void\ set(\mathcal{K}, \mathcal{V})$:

$if(keyNode[\mathcal{K}] \neq nil)$:

$\boldsymbol{node} \coloneqq keyNode[\mathcal{K}], \boldsymbol{node}.val \coloneqq \mathcal{V}$

$dll.unlink(\boldsymbol{node}), dll.addHead(\boldsymbol{node})$

$else$:

$if(keyNode.size < cap)$:

$new \coloneqq (\mathcal{K}, \mathcal{V})$

$dll.addHead(new)$

$keyNode[key] \coloneqq new$

$else$:

$lru \coloneqq dll.tai.prev$

$dll.unlink(lru)$

$keyNode[lru.key] = nil$

$new \coloneqq (\mathcal{K}, \mathcal{V})$

$dll.addHead(new)$

$keyNode[key] \coloneqq new$

Follow Up: Distributed LRU

We can maintain a hash-table that maps resource (it could be key of KV pair) to corresponding machine. Then, when a request comes in for $source_A$, it will be directed to its corresponding machine, say $machine_M$. At the $machine_M$, it does the same thing as the single LRU cache strategy.

Consistent Hashing

$shardNum = n(2^{64} - 1) \rightarrow means\ there\ are\ (2^{64} - 1)\ virtual\ node\ (vnode)$

$microShardNum = 1k$

$shard2MachineId = \{\phi\}$

$void\ addMachine(int\ machine_{id})$:

$count = 0$

$Set\langle int\rangle\ group = \{\phi\}$

$while(count < microShardNum)$:

$rid = rand.nextInt(shardNum)$

$if(shard2MachineId[rid] == null)$:

$shard2MachineId[rid] = machine_{id}$

$count = count + 1$

$group.add(rid)$

$for(int\ id: group)$:

$copy\ partial\ source\ from\ vnode[(id+1)/size]\ to\ vnode[id]$

$int\ getMachineByHash(int\ hashId)$:

$i = hashId$

$while(true)$:

$if(shard2MachineId[i] \neq null): return\ shard2MachineId[i]$

$i = (i+1)\ mod\ shardNum$

$void\ put(K\ source, V\ value)$:

$hid \leftarrow hashCode(K)\ mod\ shardNum$

$machine_{id} \leftarrow getMachineByHash(hid)$

$update(machine_{id}, source, value)$

$V\ request(K\ resource)$:

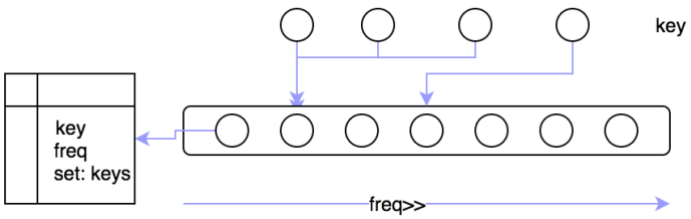
$hid \leftarrow hashCode(K)\ mod\ shardNum$

$machine_{id} \leftarrow getMachineByHash(hid)$

$request(machine_{id}, K)$

---

460. LFU Cache



---

class Node:

Node pre, next

int key, freq

keys: LinkedHashSet

class DoubleLinkedList:

```
    Node head, tail
    void addAfter(Node node, Node newNode):
    void unlink(Node node):

map ⟨int, int⟩ key2value
map ⟨int, Node⟩ key2node
DoubleLinkedList dll

void get(int key):
    if (key2value[key] ≠ null):
        increase(key)
        retrun key2value[key]
    return −1

void set(int key, int value):
    if (key2value[key] ≠ null):
        key2value[key] ← value
        increase(key)
    else:
        if (map.size > cap): removeOld()
        key2value.put(key, value)
        increase(key)

void increase(int key):
    Node nd ← key2node[key]
    if (nd ≠ nil):
        nd.keys.remove(key)
        if (nd.next == dll.tail or nd.next.freq ≠ nd.freq + 1):
            Node nx ← Node(key, nd.freq + 1)
            dll.addAfter(nd, nx)
            key2node.put(key, nx)
        elif (nd.freq + 1 == nd.next.freq)
            nd.next.keys.add(key)
            key2node.put(key, nd.next)
        if (nd.keys.size == 0): remove(nd)
```

$else\ if(dll.head.next == dll.tail\ or\ dll.head.next.freq \neq 1)$:

$Node\ nd \leftarrow Node(key = key, freq = 1)$

$nd.keys.add(key)$

$dll.addAfter(dll.head, nd)$

$key2node.put(key, nd)$

$else\ if(dll.head.next.freq == 1)$:

$dll.head.next.keys.add(key)$

$key2node.put(key, dll.head.next)$

$void\ removeOld()$:$\star$ *evict one of key in head node(least freq)*

$if(head\ is\ null)$:$return$

$int\ tobeRemoved \coloneqq nil$

$for(int\ k: head.keys)$:

$tobeRemoved \leftarrow k, break$

$key2value.remove(tobeRemoved)$

$key2node.remove(tobeRemoved)$

$if(head.keys.size == 0)$:$remove(head)$

---

432. All O'one Data Structure

$$inc(x),$$
$$dec(x),$$
$$getMaxkey(),$$
$$getMaxkey()$$

Intuition & Algorithm

$$Node\begin{cases} freq \\ Set[string]\ keys \\ prev \\ next \end{cases} \rightarrow dll\begin{cases} head \\ tail \end{cases}$$

380.Insert & Delete Get-Random O(1)

381. Insert & Delete Get-Random O(1)

$Solution$ I: $ArrayList + hashmap$

$list\langle int\rangle\ list$

$map\langle int, int\rangle\ val2index$

$insert(int\ val)$: $list.add(val)$

$delete(int\ val)$:

    $swap(list, list.size - 1, val2index[val]), list.remove(list.size - 1)$

$getrandom(void)$: $return\ list[rand.nextInt(list.size)]$

$Solution$ II: $two\ hashmap$: $val_{\rightarrow index}, index_{\rightarrow val}, count = 0$

$boolean\ insert(int\ val)$:

    $if\ (val_{\rightarrow index}[val]\ is\ null)$: $return\ false$

    $val2index[val] \leftarrow count$

    $index2val[count] \leftarrow val$

    $count := val2index.size$

$boolean\ delete(int\ val)$:

    $if\ (val2index[val]\ is\ null)$: $return\ false$

    $idx := val2index[val]$

    $val2index[val] := nil$

    $if(idx \neq count - 1)$:

        $lastvalue = val2index[count - 1]$

        $val2index[idx] := lastvalue$

        $val2index[lastvalue] \leftarrow idx$

    $else$: $index2val[idx] \leftarrow null$

    $count := val2index.size$

Design Rate Limiter

For example, no more than 100 requests per second.

$for(t\ in\ 0 \rightarrow 59)$:

    $key = event(url_{shorten}) +\ feature(ip) + |current\ ts - t|$

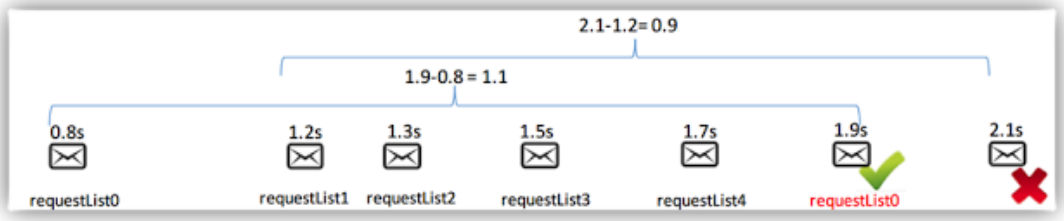
    $* event \in \{url_{request}, login, logout, register\}$

    $sum+= memchaced.get(key, default = 0)$

$check\ sum\ is\ in\ limitation$

```
interface RateLimit {
    void setQPS(int qps);
    boolean allowThisRequest()
}

public class RateLimitImpl implements RateLimit {
    private long qps_ms
    private Map<ip, Queue<int> > map
    public void setQPS(int qps):
        if (qps < 1 or qps > 1million): throw new RunException()
        qps_ms = qps * 1k
        map ← new HashMap<>
    public boolean allowThisRequest(Request req):
        boolean allowed ← false
        Q = map.getOrDefault(req.ip, new Queue<>())
        if (Q.isEmpty()):
            Q.offer(req)
        elif (Q.size() < qps_ms || req.ts − Q.peek() > 1000_ms):
            allowed = true
            while(Q.size() > 0 & req.ts − Q.peek() > 1000_ms): Q.poll()
        else: allowed = false
    return allowed
```

For example



Case I: $qps = 5, then$

$req(0.8s)$: ac ($Q = \{\boxed{0.8s}\}$)

if a request comes at 0.81s, it seems that the local $qps = \frac{2}{0.81-0.8} \gg 5(qps)$, but we should allow this request, why? because we only care how many requests comes in a window of 1 second, we

don't need to care how request distributed in the 1s window. So a sequence of request of $req\ (0.8s, 0.81s, 0.82s, 0.83s, 0.84s\})$ should be allowed under the limitation of 5 qps.

$req(1.2s)$: $ac\ (Q = \{0.8s, \boxed{1.2s}\})$

$req(1.3s)$: $ac\ (Q = \{0.8s, 1.2s, \boxed{1.3s}\})$

$req(1.5s)$: $ac\ (Q = \{0.8s, 1.2s, 1.3s, \boxed{1.5s}\})$

$req(1.7s)$: $ac\ (Q = \{0.8s, 1.2s, 1.3s, 1.5s, \boxed{1.7s}\})$

$req(1.9s)$: $ac\ (Q = \{\sout{0.8s}, 1.2s, 1.3s, 1.5s, 1.7s, \boxed{1.9s}\})$

$req(2.1s)$: $deny\ (Q = \{\sout{0.8s}, 1.2s, 1.3s, 1.5s, 1.7s, 1.9s\}\ 2.1 - 1.2 < 1s)$

$req(2.5s)$: $ac\ (Q = \{\sout{1.2s}, 1.3s, 1.5s, 1.7s, 1.9s, \boxed{2.5s}\}\ 2.5 - 1.2 > 1s)$

359. Logger Rate Limiter

```
boolean shouldPrintMessage(String msg, int ts):
    if (map[msg] == null || ts − map[msg] ≥ 10s):
        map[msg] = ts
        return true
    return false
```

636. Exclusive Time of Functions

Solution: "start" → push & "end" → pop

```
int[] result = new int[n];
Stack⟨int⟩ stack = new stack <> ();
int prev = 0;
for(String log: logs):
    String[ ] token = log.split(":");
    int funcId = Integer.parseInt(token[0]);
    boolean start = token[1].equals("start");
    int ts = Integer.parseInt(token[2]);
    if (start) :
        //calculate outer function time cost
        if(! stack.empty): re[stack.peek] += ts − prev;
        stack.push(funcId);
        prev = ts;
```

$$else: \ //calculate\ inner\ function\ time\ cost$$

$$if(!stack.empty): re[stack.pop] \mathrel{+}= ts - prev + 1$$

$$prev = ts + 1;$$

$$return\ result;$$

Design PokemonGo.

Design Type-head

$$TrieNode\begin{cases} next[26] \\ maxheap(TrieNode) \end{cases} (size\ of\ maxheap \leq 10)$$

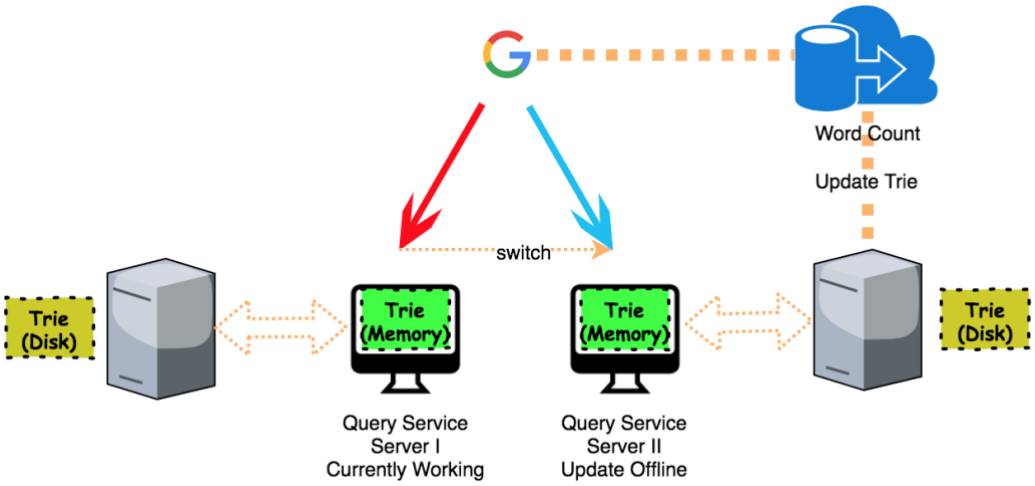
$$req \leftrightarrow \boxed{\begin{matrix} QueryServices \\ (trie) \end{matrix}} \leftrightarrow \boxed{\begin{matrix} Data\ Collection \\ (word, freq) \end{matrix}} \xleftrightarrow[ask\ search\ data\ once\ a\ week]{} search\ logs$$

Workable solution: when user types a prefix, say *"am"* into google search textbox, it automatically makes a request to the *QueryServices*, and the *QueryServices* scan the *"am"* char by char in the Tire. At node of "m", there is a list of nodes, say *"amazon"*,"amaze", *etc.* which is associated with it ("am") are the top 10 hot words starting with prefix *"am"*.

Since the hot words will be changed every day, so we need to update the trie built so far with the most up-to-date searched words or logs, thus the *Data Collection Service* comes into use for this purpose. This service works at servers to ask data from search logs which are stored in database, doing kind of like sql-queries thing:

```
SELECT Word, Count(Word) AS CNT
FROM WordTable
GROUP BY Word
WHERE DATEDIFF(@CurrTimeStamp - TimeStamp) < 7
HAVING CNT > 1b
```

At this stage, **Data Collection Service** maintains a "bigtable", then it begins to update the trie. Because we cannot interrupt a working **Query Service** machines, we can copy the trie from disk to disk, and load the trie into another machine's memory. Last, we update the trie using the **most up-to-date hot words big-table.** After it finished, we can switch the type-head query flows goes into the updated-trie machine.



Scalability: hire multiple Query Service machine

For example, the word $amax$ has been search 20b times, then we need to update it to trie four time (because $len('amax') = 4$). We need to update $4\ prefix: 'a', 'am', 'ama', 'amax'$. Here, we can compute hash value for all the four prefix, and use $machine\ id = hashvalue\ \%\ machines \cdot number$ or consistent hashing to target the query service machine.

Storage for search words log

For example, a word will be counted only if its occurrence is more than $1k$.

Reservoir Sampling

382. Linked List Random Node

$ListNode\ p \leftarrow head, e = 1, result = null$

$while(p \neq null)$:

    $if(rand.nextInt(e{+}{+}) = 0): result = p$

    $p = p.next$

$return\ result.val$

---

398. Random Pick Index

$e \coloneqq 1, re \coloneqq -1$

$for(i = 0 \rightarrow len(A) - 1)$:

$if(A[i] = \mathcal{T}\ \&\ rand.nextInt(e{+}{+}) = 0): re \coloneqq i$

$return\ re$

---

336. Palindrome Pairs

Given a list of unique words, find all pairs of distinct indices (i, j) such that $words[i] + words[j]$ is palindromic string.

Solution: $map(words[i]) \rightarrow \{s_0, s_1, \cdots, s_n\}, words[i] + s_k$is palindromic string.

Dynamic Programming

238. Product of Array Except Self

$l_i = l_{i-2} \times a_{i-1}$,

$r_i = r_{i+2} \times a_{i+1}$

Minimum number deletion chars ForUsAll

making the all characters in ascending order after delete. For example, $str = 'banana'$, delete minimum number characters $'b', 'n', 'n' \rightarrow 'aaa'$

$f = (array, size = 26, default = 0)$

$for(i = 0 \rightarrow s.length - 1)$:

    $temp = 1$

    $for(j = ' a' \rightarrow s[i])$:

        $temp = \max(temp, f_j + 1)$

    $f[s[i]] = temp$

    $result = \max(f[s[i]], result)$

---

10. Wildcard Matching

Q. '?' matches 1 character and '*' matches 0,1, multiple characters.

$f[0,0] = true$

$for(i = 1 \rightarrow len(t)): f[0,i] := f[0,i-1]\ \&\ s[i-1] = \star$

$for(i = 1 \rightarrow len(s))$:

    $for(i = 1 \rightarrow len(t))$:

        $if(t[j-1] = ?\ or\ s[i-1] = t[j-1]): f[i,j] = f[i-1,j-1]$

        $elif(t[j-1] = \star): f[i,j] = f[i-1,j-1]\ \&\ f[i,j-1]\ \&\ f[i-1,j]$

K Sum Problem

Intuition & Algorithm

Define $f[i,j,v]$ as the number of options of selecting j numbers from the first i numbers that sum to v. So for the $(i-1)^{th}$ number, there two options can be selected. Option #1, not selecting th $(i-1)^{th}$ number, s $f[i,j,v] := f[i,j,v] + f[i-1,j,v]$o. Option #2, selecting the $(i-1)^{th}$ number, so $f[i,j,v] := f[i,j,v] + f[i-1,j-1,v-A[i-1]]$

```
for(i = 1 → n):
    for(j = 1 → k):
        for(v = target → A[i − 1]):
            f[j, v] ≔ f[j, v] + f[j − 1, v − A[i − 1]]
```

68. Text Justification Uber

Solution: Greedy Algorithm, fit as many words as possible per line

Follow Up: Balance the amount of Empty Space Allocated per line

For example, when justify the text $'aaa\ bb\ cc\ ddddd'$ with the maximum 6 characters per line, there are at-least two ways of justification.

a	a	a		b	b
c	c				
d	d	d	d	d	

a	a	a			
b	b		c	c	
d	d	d	d	d	

The cost of empty space of first plan is: $1 + 4^3 + 1^3 = 64$, while that of second plan is $3^3 + 2^3 + 1^3 = 36$, obviously, the second plan is better meaning the empty space allocated per line is more balanced.

Intuition & Algorithm

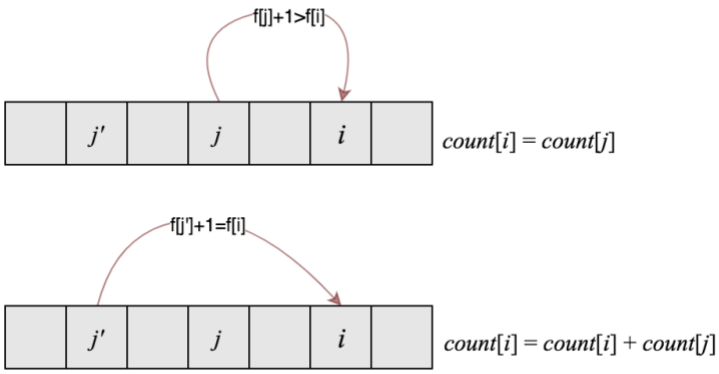
Dynamic Programming, first we compute costs of all possible lines in a 2D table $lc[][]$, The value $lc[i][j]$ indicates the cost to put words from i to j in a single line where i and j are indexes of words in the input sequences. If a sequence of words from i to j cannot fit in a single line, then $lc[i][j]$ is considered ∞ (to avoid it from being a part of the solution). Once we have the $lc[][]$ table constructed, we can calculate total cost using following recursive formula. In the following formula, $cost[i]$ is the optimized total cost for arranging words from $1\ to\ i$.

$$cost_i = \begin{cases} 0, if\ i == 0 \\ \min_{1 \le j \le i}(cost_{j-1} + lc_{j,i}), if\ i > 0 \end{cases}$$

```
void text · justification (String[] words, int maxChar)
    n = words.length
    # extra: number of extra space if (words[i], ··· words[j]) are put in one single line
    int[ ][ ] extra = [n][n]
    # lc: cost of a line which contains (words[i], ··· , words[j])
    int[ ][ ] lc = [n][n]
    int[ ] cost = [n + 1]
    mx = 2^31 − 1
    for(i = 0 → n − 1):
        for(j = i → n − 1):
            extra[i, j] = maxCharLimit − (∑_i^j len(words[k]) + j − i)

    for(i = 0 → n − 1):
        for(j = 0 → n − 1):
            if(extra[i, j] < 0): lc[i, j] := 2^31 − 1
            elif(j = n & extra[i, j] ≥ 0): lc[i, j] = 0 ⋆ in case of last line
            else: lc[i, j] = (extra[i, j])^2

    cost[0] = 1 ⋆ if there is no more word to be dealt with
    for(i = 1 → n):
        cost[i] = 2^31 − 1
        for(pre = 1 → i − 1):
            if (cost[pre] ≠ mx  lc[pre − 1, i − 1] ≠ mx
                                                    cost[pre] + lc[pre − 1, i − 1] < cost[i]):
                cost[i] := cost[pre] + lc[pre − 1, i − 1]
                path[i − 1] = pre − 1

print · solution(path, idx):
    do:
        print(idx → path[idx])
        idx = path[idx] − 1
    while(path[idx] ≠ 0)
```

673. Number of Longest Increasing Subsequence Facebook

Given an unsorted array of integers, find the number of longest increasing subsequence.



Intuition & Algorithm

Apply DP method by defining $f[i]$ as the LIS ending up with index i. Also, define $counts[i]$ as the number of LIS ending up with index i.

$int[\,]\, f \coloneqq [n]$

$int[\,]\, counts \coloneqq [n], counts[i] \coloneqq 1$

$\mathcal{LIS} \coloneqq 0$

$for(i = 0 \to n-1)$:

    $mx \coloneqq 1$

    $for(j = 0 \to i-1)$:

        $if(A[j] < A[i]\ \&\ f[j] + 1 > mx)$:

            $counts[i] \coloneqq counts[j]$

            $mx \coloneqq f[j] + 1$

        $elif(A[j] < A[i]\ \&\ f[j] = mx)$:

            $counts[i] \coloneqq counts[i] + counts[j]$

    $f[i] \coloneqq mx$

    $\mathcal{LIS} \coloneqq \max(\mathcal{LIS}, f[i])$

$re \coloneqq 0$

$for(i = 0 \to n-1)$:

    $if(f[i] = mx)$: $re \coloneqq re + counts[i]$

$return\ re$

---

10. Regular Expression Matching

Intuition & Algorithm

'.' Matches 1 character, $\{e\}^{*} matches\ \{0,1,\infty\}\ character\ 'e'$

$int[\,][\,]\ f = [len(s)+1][len(t)+1]$

$f[0,0] = true, f[0,1] = false$

$for(i = 2; i \le len(\mathcal{T})): f[0,i] \coloneqq f[0,i-2]\ \&\ s[i-1] = \star$

$for(i = 1 \to len(\mathcal{S})):$

  $for(i = 1 \to len(t)):$

    $if(\mathcal{T}[j-1] = \star):$

      $if(\mathcal{S}[i-1] = \mathcal{T}[j-2]\ ||\ \mathcal{T}[j-2] = \cdot):\star\ \mathcal{S}[i-1]\ can\ match\ \mathcal{T}[j-2]$

        $f[i,j] \coloneqq f[i,j]\ ||\ (f[i-1,j-2]\ ||\ f[i-1,j]\ ||\ f[i,j-2])$

      $else:\star\ \mathcal{S}[i-1]\ doesn't\ match\ \mathcal{T}[j-2]$

        $f[i,j] \coloneqq f[i,j]\ ||\ f[i,j-2] \Rightarrow threat\ (\mathcal{T}[j-2], \mathcal{T}[j-1])\ as\ (\mathcal{T}[j-2])^{0}$

    $elif(\mathcal{T}[j-1] = \cdot):$

      $f[i,j] \coloneqq f[i,j]\ ||\ f[i-1,j-1]$

    $elif(\mathcal{T}[j-1] = \mathcal{S}[i-1]):$

      $f[i,j] \coloneqq f[i,j]\ ||\ f[i-1,j-1]$

---

97. Interleaving String

Given three strings s_1, s_2, s_3,determine if s_3 is formed by interleaving s_1, s_2

Intuition & Algorithm

$int[\,][\,]\ f = [len(s_1+1)][len(s_2+1)]$

$f[i,0] = s_1[0{:}i-1] = s_3[0{:}i-1] \to true{:}\ false$

$f[0,j] = s_2[0{:}j-1] = s_3[0{:}j-1] \to true{:}\ false$

$for(i = 1 \to len(s_1)):$

  $for(j = 1 \to len(s_2)):$

    $if(f[i-1,j]\ \&\ s_1[i-1] = s_3[i+j-1]): f[i,j] = true$

    $if(f[i,j-1]\ \&\ s_2[j-1] = s_3[i+j-1]): f[i,j] = true$

$return\ f[len(s_1)][len(s_2)]$

---

5. Longest Palindromic Substring

Solution I: $f_{i,j} = f_{i+1,j-1}$ & $s_{i+1} = s_{j-1}$ Time Complexity: $O(K^2)$, Space Cost: $O(K^2)$

Solution II: Time Complexity: $O(K^2)$, Space Cost: $O(1)$

$maxLen = 0, re = (l = 0, r = 0)$

$for(i = 0; i < s.length)$:

    $int[\,]\ p \leftarrow centerAt(s, i, i)$ $\star$ *find the left & right boundary of* s *s.t.* $s[p_0, p_1]$ *is palindromic*

    $int[\,]\ q \leftarrow centerAt(s, i, i+1)$ $\star$ *find the left & right boundary s.t.* $s[p_0, p_1]$ *is palindromic*

    $if(p[1] - p[0] > maxLen)$:

        $maxLen = p[1] - p[0]$

        $(re.l, re.r) = (p[0], p[1])$

    $if(q[1] - q[0] > maxLen)$:

        $maxLen = q[1] - q[0]$

        $(re.l, re.r) = (q[0], q[1])$

$return\ s[re.l, re.r]$

---

516. Longest Palindromic Subsequence

Given a string s, find the longest palindromic subsequence's length in s. You may assume that the maximum length of s is 1000.

410. Split Array Largest Sum

Split the array into m consecutive subarrays s.t. the largest subarray's sum smallest.

Intuition & Algorithm

Binary-Search by initializing the range $\mathcal{L} \coloneqq \min(A[i]), \mathcal{R} \coloneqq \sum_0^{n-1} A[i]$. Then, each time picking up the middle value as the *guess*, and testify whether we can split array into m chunks with the largest sum equals to the *guess*. If we can, we continue test smaller largest sum by $\mathcal{R} \coloneqq mid - 1$. Otherwise, $\mathcal{L} \coloneqq mid + 1$

$int\ splitArray(int[\,]\ A, int\ m)$:

    $\ell ong\ l \coloneqq \max(A[i]), \forall i \in [0, n-1]$

    $\ell ong\ r \coloneqq \sum_0^i A[i]$

    $re \coloneqq r$

$while(l \le r)$:

$mid \coloneqq \frac{l+r}{2}$

$sum \coloneqq 0, chunks \coloneqq 1$

$for(i = 0 \to n-1)$:

$if(sum + A[i] > mid)$:

$chunks \coloneqq chunks + 1$

$sum \coloneqq A[i]$

$else: sum \coloneqq sum + A[i]$

$if(chunks \le m)$:

$re \coloneqq \min(re, mid)$

$r \coloneqq mid - 1$

$else: l \coloneqq mid + 1$

$return\ (int)\ re$

---

53. Maximum Subarray

$global[i] = \max(global[i-1], local[i])$

$local[i] = \max(local[i-1] + a[i], a[i])$

Constant Space Solution

$max \cdot here = A[0], re = A[0]$

$for(i = 1 \to A.length;)$:

$max \cdot here = \max(maxh \cdot here, 0) + A[i]$

$re = \max(re, max \cdot here)$

Follow Up: Maximum Subarray with At-least Length of K

$for(i = 0 \to k-1): sum = sum + a[i]$

$presum = 0, premin = 0, re = sum$

$for(i = k \to n-1)$:

$sum = sum + a[i]$

$presum = presum + a[i-k]$

$premin = \min(premin, presum)$

$re = \max(re, sum - premin)$

---

691. Stickers to Spell Word IXL

42. Trapping Rain Water

$water[i] = \min\left(left^{high}[i], right^{hight}[i]\right) - height[i]$

$re \coloneqq re + water[i]$

62. Unique Paths & 63. Unique Path II

$f_{i,j} \leftarrow grid_{i,j} == 0 ? 0 : f_{i-1,j} + f_{i,j-1}$

174. Dungeon Game

$f[m-1, n-1] = 1$

$choice_1 \leftarrow f_{i+1,j} - dungeon_{i,j} \geq 1 ? f_{i+1,j} - dungeon_{i,j} : 1$

$choice_2 \leftarrow f_{i,j+1} - dungeon_{i,j} \geq 1 ? f_{i,j+1} - dungeon_{i,j} : 1$

$f[i,j] = \min(choice_1, choice_2)$

---

64. Minimum Path Sum

$f[i,j] = \min(f[i,j-1], f[i-1,j]) + grid[i,j]$

474. Zeros & Ones

Find the maximum number of strings that you can form with given m $0s$ and n $1s$. Each 0 and 1 can be used at most once.

Intuition & Algorithm

Define$f[i,j]$ as the max number of strings that we can form with given i $0s$ and j $1s$. Apply "01" backpack problem solver.

$$f[i,j] = max(f[i - \#0(s[k]), j - \#1(s[k])]) + 1$$

$for(k = 1; k \leq n;)$

    $\#0 = count \cdot zero(s[k]), \#1 = count \cdot one(s[k])$

    $for(i = m \rightarrow \#0)$:

        $for(j = n \rightarrow j \geq \#1)$:

            $f[i,j] = \max(f[i - \#0(s[k]), j - \#1(s[k])]) + 1$

---

322. Coin Change

Find minimum amount of coin change making up total amount, each coin can be used multiple times.

Intuition & Algorithm

Apply multiple backpack problem solver.

$for(i = 1 \to n)$:

    $for(j = value(i-1) \to total \cdot amount)$:

        $f[j] = min(f[j - values[i-1]]) + 1$

---

279. Perfect Square Google

$f[n] = \min(f[n-k^2]) + 1, \forall k \in [1, \sqrt{n}]$

$int\ DP(int\ n, int[\ ]\ f)$:

    $if(n = 0): return\ 0$

    $if(f[n] \neq nil): return\ f[n]$

    $for(v \coloneqq 0 \to A[i])$:

        $if(A[i] \leq v): f[i,v] \coloneqq \min(f[i,v], f[i-1, v-A[i]] + 1)$

---

472. Concatenated Words

$f[i] = f[j]\ \&\ wordDict[s[j+1:i]] \neq nil$

140. Word Break II

139. Word Break II Google Uber Twitter Snapchat Dropbox

$bool[\ ]\ f = [len(s)]$

$for(i = 0 \to len(s) - 1)$:

    $if(dict[s[0:i]] \neq nil)$:

        $f[i] = true, continue$

    $for(j = i - 1 \to 0)$:

        $if(dict[s[j+1:i]] \neq nil\ \&\ f[j]): f[i] = true, break$

$re = [\phi]^{string}, cand = [\phi]^{string}$

$DFS(re, cand, dict, s, index)$

$return\ re$

$DFS(re, cand, dict, s, index)$:

$if\big(index = len(s)\big)$:

$re.add(cand[i] + \text{" "},) \forall i \in [0, len(cand) - 1]$

$return$

$for(next = index \to len(s) - 1)$:

$if\big(f[next]\ \&\ dict\big[s[index{:}next]\big] \neq nil\big)$:

$cand.add(s[index{:}next])$

$DFS(re, cand, dict, s, next + 1)$

$cand.remove(len(cand) - 1)$

---

131. Palindrome Partitioning

132. Palindrome Partitioning II

$palindrome[i, j] \coloneqq palindrome[i + 1, j - 1]\ \&\ s[i] = s[j]$

$for(i = 0 \to len(s) - 1)$:

$cut[i] \coloneqq (palindrome[0, i] = \mathcal{T}rue) \to 0{:}\, i$

$for(pre = 0 \to i - 1)$:

$if\,(palindrome[pre + 1, i] = \mathcal{T}rue){:}\, cut[i] \coloneqq \min(cut[i], cut[pre] + 1)$

$cut[i] \coloneqq \min\big(cut[i], cut[pre] + (i - pre)\big)$

---

416. Partition Equal Subset Sum eBay

$$half = \frac{(\sum_0^{n-1} A[i])}{2}$$

$for(i = 1 \to n)$:

$for(v = half \to A[i - 1])$:

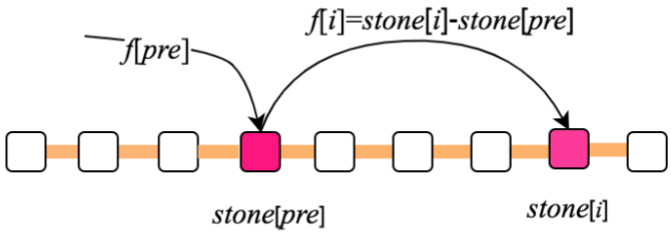
$f[v] \coloneqq f[v]\ ||\ f\big[v - A[i - 1]\big]$

---

403. Frog Jump Snapchat

Given a list of stones' positions (in units) in sorted ascending order, determine if the frog is able to cross the river by landing on the last stone. Initially, the frog is on the first stone and assume

the first jump must be 1 unit. If the frog's last jump was k units, then its next jump must be either k - 1, k, or k + 1 units. Note that the frog can only jump in the forward direction.



Intuition & Algorithm

The idea here is to maximize the jumps reach to $stone[i]$, so we define $f[i]$ as the maximal jumps reach to $stone[i]$.

$f[0] \coloneqq 0, f[1] \coloneqq 1$

$for(i = 2 \to n - 1)$:

  $for(pre = 0 \to i - 1)$:

    $if(f[pre] < 0)$: $continue$ ⋆ *means this guy cannot make to pre*

    $curstep \coloneqq stone[i] - stone[pre]$

    $if(f[i] = curstep \pm 1 \;||\; f[i] = curstep)$:

      $f[i] \coloneqq curstep$

      $break$

$return\ f[i] > 0 \to True : False$

---

376. Wiggle Subsequence

$f_{min}[i] = \max(f_{max}[j]) + 1, if\ A[j] > A[i]$

$f_{max}[i] = \max(f_{min}[j]) + 1, if\ A[j] < A[i]$

$re = \max(f_{min}[i], f_{max}[i])$

---

120. Triangle Google

$f[i,j] = \max(f[i+1,j], f[i+1,j+1]) + triangle[i,j]$

368. Largest Divisible Subset

$sort(A)$

$f[i] = \max(f[j]) + 1, \forall j \in [0, i-1], A[i] \,\%\, A[j] = 0$

$int[\,]\, pre = [n], int[\,]\, f = [n]$

$pre[i] \coloneqq -1, \forall i \in [0, n-1]$

$f[i] \coloneqq 1, \forall i \in [0, n-1]$

$for(i = 0 \to n-1)$:

    $\mathcal{M}ax \coloneqq -2^{31}, maxj = -1$

    $for(j = 0 \to i-1)$:

        $if(A[i] \,\%\, A[j] = 0 \;\&\; f[j] > \mathcal{M}ax)$:

            $\mathcal{M}ax \coloneqq f[j], maxj \coloneqq j$

    $if(maxj \neq -1)$:

        $pre[i] = maxj, f[i] = \mathcal{M}ax + 1$

$maxi \coloneqq -1, max \coloneqq -1$

$for(i = 0 \to n-1)$:

    $if(f[i] > max)$:

        $max \coloneqq f[i], maxi := i$

$pos \coloneqq maxi$

$\mathcal{D}o: re.add(A[p]), p \coloneqq pre[p]$

$while(p \neq -1)$

$return\ reverse(re)$

Stock Problem Series

121. Best Time to Buy & Sell Stock I

$dif[i] \coloneqq prices[i] - prices[i-1], \forall i \in [1, n-1]$

$return\ maxSumSubarray(dif)$

122. Best Time to Buy & Sell Stock II

Find all ascending subarray $prices[i{:}\,j]$ such that $prices[i] < \cdots < prices[j]$

$$result \coloneqq result + \sum_{i}^{j} prices[p]$$

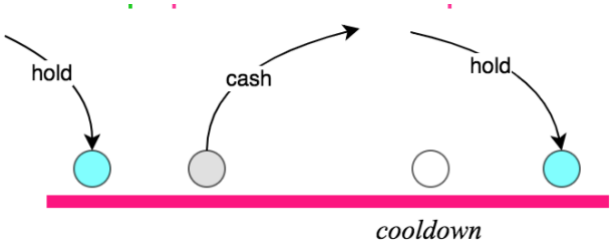
123. Best Time to Buy & Sell Stock III

188. Best Time to Buy & Sell Stock IV

$global[i,j] \coloneqq \max(global[i-1,j], local[i,j])$

$local[i,j] \coloneqq \max(local[i-1,j], global[i-1,j-1]) + dif[i]$

309. Best Time to Buy & Sell Stock with Cooldown Google



$hold \coloneqq -prices[0], cash \coloneqq 0, cooldown \coloneqq 0$

$for(i = 1 \to len(prices) - 1)$:

$temp \coloneqq hold$

$\star$ *either still hold when it's held at previous day,*

$\star$ *or buy a new share of stock when previous day is cooldown day.*

$hold \coloneqq \max(hold, cooldown - prices[i])$

$\star$ *if today is cooldown day, then previous day must either be cooldown day or selling day*

$cooldown \coloneqq \max(cooldown, cash)$

$\star$ *if today is selling day, then previous day must either be selling day or holding day*

$cash \coloneqq \max(cashsell, temp + prices[i])$

$return \max(sell, cooldown)$

---

714. Best Time to Buy and Sell Stock with Transaction Fee Facebook Bloomberg

At the end of the i^{th} day, we maintain *cash*, the maximum profit we have sold the stock at-hand, and *hold*, the maximum profit we could have if we owned a share of stock.

$max \cdot profit(prices, fee)$:

$nothold = [n], hold = [n]$

$nothold[0] = 0, hold[0] = -prices[0]$

$for(i = 1 \to len(prices) - 1)$:

$nothold[i] \coloneqq \max(nothold[i-1], hold[i-1] + prices[i] - fee)$

$hold[i] \coloneqq \max(hold[i-1], nothold[i-1] - prices[i])$

$return\ cash$

Constant Space Optimization

$max \cdot profit(prices, fee)$:

$\star$ *cash*: max *profit when no share of stock at hand*

$\star$ *hold*: max *profit when holding a share of stock*

$cash = 0, hold = -prices[i]$

$for(i = 1 \to len(prices) - 1)$:

$\star$ *sell current stock get profit of* $prices[i]$, *and minus the transaction fee*

$cash = \max(cash, hold + prices[i] - fee)$

$\star$ *buy current stock with* $prices[i]$

$hold = \max(hold, cash - prices[i])$

$return\ cash$

---

198. House Robber I LinkedIn Airbnb

$int[\,]\ rob(int[\,]\ A)$:

$if(len(A) = 1)$: $return\ A[0]$

$yes = A[0], no = 0, re \coloneqq yes$

$for(i = 1 \to n - 1)$:

$temp \coloneqq no$

$no = \max(yes, no)$

$yes = no + A[i]$

$re \coloneqq \max(yes, no)$

$return\ re$

---

213. House Robber II (Rob in a Circle)

$re \coloneqq \max\big(rob(A, 0, n-2), rob(A, 1, n-1)\big)$

337. House Robber III (Rob in a BT)

$re \coloneqq -2^{31}$

$int[\,]\ maxRob(TreeNode\ o)$:

$int[\,]\ left = maxRob(o.left)$

$int[\,]\ right = maxRob(o.right)$

$notRob = \max(left_0, left_1) + \max(right_0, right_1)$

$rob = left_0 + right_0 + o.val$

$rob[0], rob[1] = notRob, rob$

$re = \max(re, rob[0], rob[1])$

$return\ rob$

---

70. Climbing Stairs Apple Adobe

$f_i = f_{i-1} + f_{i-2}, f_0 = 0, f_1 = 1$

Apply the same formula as Fibonacci equation, can use fast exponentiation matrix algorithm.

$$\begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^n = \begin{pmatrix}F_{n+1} & F_n\\ F_n & F_{n-1}\end{pmatrix}$$

$$\begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^n = \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^{\frac{n}{2}} \cdot \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^{\frac{n}{2}} \cdot \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^{(n\&1)}$$

$$F = \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}\ M = \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}$$

---

72. Edit Distance

$f[i,j] \coloneqq f[i-1, j-1], word_1[i] = word_2[j]$

$f[i,j] \coloneqq \min(f[i-1,j], f[i,j-1], f[i-1,j-1]) + 1$

115. Distinct Subsequences Google

$s[0:i-1]\ contains\ how\ many\ \#\ of\ t[0:j-1]$

$f_{i,j} = f_{i-1,j-1} + f_{i-1,j}\ (if\ s_{i-1} = t_{j-1})$

$f_{i,j} = f_{i-1,j}\ (if\ s_{i-1} \neq t_{j-1})$

87. Scramble String

$dfs(s, t, ls, rs, lt, rt)$

95. Unique Binary Search Trees I Snapchat

```
int[ ][ ] f := [n][n]
for(i = 0 → n − 1):
    for(j = 0 → i): f[i,j] := 1
for(len = 2 → n):
    for(i = 0 → i + len ≤ n):
        j := i + len − 1
        for(k = i → j):
            if(k = i): f[i,j] := f[i,j] + f[k + 1,j]
            elif(k = j): f[i,j] := f[i,j] + f[i,k − 1]
            else: f[i,j] := f[i,j] + f[i,k − 1] ⋆ f[k + 1,j]
```

96. Unique Binary Search Trees II

```
List⟨TreeNode⟩ dfs(l,r):
    if(l > r): return null
    List⟨TreeNode⟩ roots = {ϕ}
    for(k = l; k < r; )
        List⟨TreeNode⟩ lchilds = dfs(l,k − 1)
        List⟨TreeNode⟩ rchilds = dfs(k + 1,r)
        for(TreeNode lc: lchilds):
            for(TreeNode rc: rchilds):
                TreeNode o = new TreeNode(nums[k])
                o.left = lc
                o.right = rc
                roots.add(o)
return roots
```

304. Range Sum Query 2D – Immutable
308. Range Sum Query 2D - Mutable

Intuition & Algorithm #1

Fenwick Tree

Time Cost: $O\big(log(m) \star log(n)\big)$ per update or get sum operation.

```
class FenwickTree
    int R, C
    int[ ][ ] sum
    public FenwickTree(R, C): sum = [R + 1][C + 1]
    void update(int r, int c, int delta):
        for(x = r; x ≤ R; x := x + x & (−x)):
            for(y = c; y ≤ C; y := y + y & (−y)):
                sum[x, y] := sum[x, y] + delta
    int getSum(r, c):
        for(x = r; x ≥ 1; x := x − x &(−x)):
            for(y = c; y ≥ 1; y := y − y &(−y)):
                re := re + sum[x, y]
```

Intuition & Algorithm #2

Compress the 2d matrix into 1d array, then apply the algorithm the same as "find subarray with largest sum".

Time Cost: $O(m \star n)$ for initialization, $O(m)$ for update and $O(n)$ for get-sum

```
for(j = 0 → len(mat[0]) − 1):
    colsum[j, 0] := mat[i, j]
    for(i = 1 → len(mat) − 1):
        colsum[j, i] = colsum[j, i − 1] + mat[i, j]
sumRegion(r1, c1, r2, c2):
    for(c = c1 → c2):
        re := re + colsum[c, r2] − colsum[c, r1] + mat[r1, c]
update(r, c, val):
    for(i = r; i < matrix.length; ):
        colSum_{c,i} += val − matrix_{i,c}
```

303. Range Sum Query Immutable

307. Range Sum Query Mutable

$sum_i = arr_i + sum_{i-1}$

Mutable: Segment tree ($avg \log(n)\ time$)

$buildSegmentTree(int\ l, int\ r)$:

$if(l > r)$: $return\ null$

$mid \leftarrow l + ((r - l) \gg 1)$

$Node\ o \leftarrow new\ Node(l, r)$

$o.left \leftarrow build(l, mid)$:

$o.right \leftarrow build(mid + 1, r)$

$return\ o$;

$update(Node\ o, int\ pos, int\ val)$:

$if(o.l == o.r\ \&\ o.l == pos)$: $o.sum = val; return;$

$mid = l + ((r - l) \gg 1)$

$if(pos \leq mid)$: $update(o.left, pos, val)$

$else$: $update(o.right, pos, val)$

$o.sum\ +\!= o.left.sum + o.right.sum$

$querySum(Node\ o, int\ from, int\ to)$:

$if(o.l == from\ \&\ o.r == to)$: $return\ o.sum$

$mid = l + ((r - l) \gg 1)$

$if(to \leq mid)$: $return\ querySum(o_{left}, from, to)$

$elif(from \geq mid)$: $return\ querySum(o_{right}, from, to)$

$else$: $return\ querySum\big(o_{left}, from, mid\big) + querySum(o_{right}, mid + 1, to)$

---

312. Burst Balloons Google Snapchat

Intuition & Algorithm

Add two balls (value=1) to the head & tail of ball list. By defining $f[i, j]$ as the maximum score can get from $ball[i{:}\,j]$. Suppose the last balloon to be removed is $ball[k]$, then we have such formula: $f[i, j] = \max(f[i, k] + f[k, j] + a[i] \star a[j] \star a[k])\,, \forall k \in [i, j]$

$int\ maxCoins(int[\ ]\ nums)$:

$N \coloneqq len(nums)$

$int[\ ]\ A \coloneqq [N + 2]$

$A[0] = A[N + 1] = 1$

$for(i = 0 \rightarrow len(nums) - 1)$: $A[i + 1] = nums[i]$

$int[][]\ f \coloneqq [N+2][N+2]$

$for(len = 2 \to N+2)$:

$for(i = 0 \to i + len \leq N+2)$:

$j \coloneqq i + len - 1$

$for(k = i+1 \to j-1)$:

$f[i,j] \coloneqq f[i,j] + f[i,k] + f[k,j] + A[i] \star A[j] \star A[k]$

$return\ f[0, N+1]$

---

354. Russian Doll Envelopes

Solution: Sort envelopes by width, then by length if two envelopes share the same width

435. Non-overlapping Intervals

Sort the envelopes/intervals list (first length, then width), then apply LIS mode algorithm.

300. Longest Increasing Subsequence

$O(n^2)\ solution: LIS\ mode\ algorithm$

$O(n \cdot \log(n))\ solution$:

$longest \cdot increasing \cdot subseq(arr: type = int\ array)$:

$f = array_{1d}(default = 0)$

$len = 0$

$for(int\ x: arr)$:

$pos = Arrays.binarySearch(f, 0, len, x)$

$pos = pos < 0 ? -(pos+1) : pos$

$f[pos] = x$

$if(pos = len): len = len + 1$

$return\ len$

---

221. Maximal Square Facebook Apple Airbnb

$\mathbb{f}[i,j] \coloneqq min(\mathbb{f}[i-1,j], \mathbb{f}[i,j-1], \mathbb{f}[i-1,j-1]) + 1$

674. Longest Continuous Increasing Subsequence Facebook

$\mathbb{f}[i] \coloneqq \mathbb{f}[i-1] + 1, if\ \mathcal{A}[i] = \mathcal{A}[i-1] + 1$

$\mathbb{f}[i] \coloneqq 0, otherwise$

651. 4 Keys Keyboard Google Microsoft

(A, Ctrl-A, Ctrl-C, Ctrl-V), print as much 'A' as possible

Intuition & Algorithm

Define$f[i]$ as the maximum number of A's printed with i steps. Assume we already know how many A's can be printed with the best strategy in j steps, namely $f[j]$. It is clearly that the current best strategy is to collect all the A's already have (Ctrl-A), then copy all of them (Ctrl-C) and finally paste them back to the screen (Ctrl-V) one time or multiple times. So it takes at-least 3 steps to finish this series. For example, $i = 10, j = 6$, e, then the best strategy here is Ctrl-A, Ctrl-C, Ctrl-V, Ctrl-V. As a result, we can got $f[j] \star (10 - 6 - 1) = 3 \star f[j]$.

$f[i] = \max\big(f[j] \star (i - j - 1)\big), \forall j \in [0, i - 3]$

650. 2 Keys Keyboard Microsoft

the minimum step of printing n 'A' s

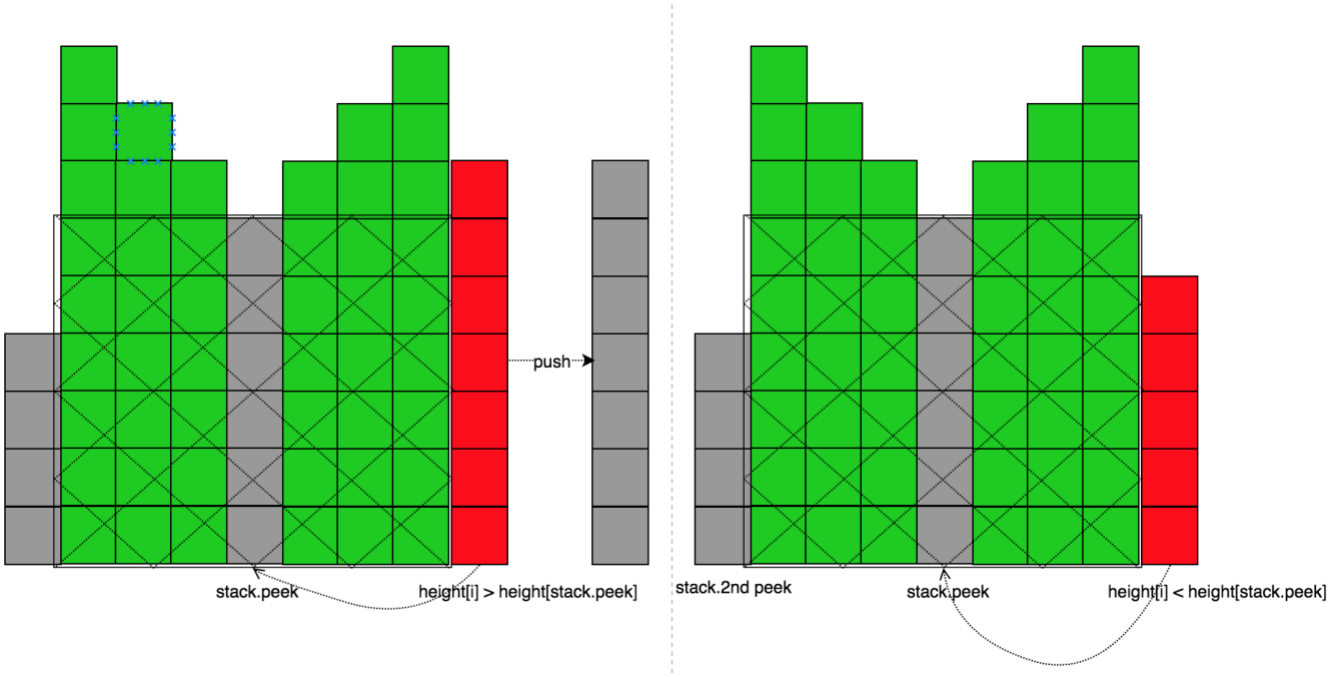
Intuition & Algorithm

CopyAll & Paste, print as much 'A' as possible. Assume the minimum number of steps for printing j A's is $f[j]$. Then the best strategy is $copyall, paste, \cdots$. For example, $i = 9, j = 3,$ then the minimum cost is$f[i] = f[j] + \frac{9}{3} = f[j] + 3$ because a series of $copyall, paste, paste$ action is required.

$f[i] = \min\left(i, f[j] + \frac{i}{j}\right), \forall j, f[i] = k \star f[j]$

85. Maximal Rectangle

84. Largest Rectangle in Histogram Facebook



Intuition & Algorithm

Always maintain a stack which maintains the ascending order of $height[i]$, as the above diagram suggests, the maximal rectangular area form by $stack.peek$ is:

$area = (\hbar[st.peek]) \star (i - st.2nd\ peek - 1)$

$largestRectangularArea(int[\,]\ \hbar)$:

$re \coloneqq 0, st \coloneqq Stack$

$\star\ append\ h[n] = -1 \rightarrow very\ impotant$

$for(i = 0 \rightarrow \hbar.length)$:

$\hbar eight \coloneqq (i = \hbar.length) \rightarrow -1 : \hbar[i] \Rightarrow VERY\ IMPORTANT$!!!!

$while(\sim st.empty\ \&\ \hbar[st.peek] > \hbar eight)$:

$top \coloneqq st.pop$

$if\,(st.empty) : re = \max\big(re, \hbar[top] \star (i - st.peek - 1)\big)$

$else : re \coloneqq \max(re, \hbar[top] \star i)$

$st.push(i)$

$return\ re$

---

363. Max Sum of Rectangle No Larger Than k Google

Intuition & Algorithm

Convert 2d problem into “find max subarray no larger than k”

```
for(j = 0 → n − 1):
    col[j, 0] = mat[i, j]
    for(i = 1 → m − 1):
        col[j, 0] := col[j, i − 1] + mat[i, j]

re = 0
for(r1 = 0 → m − 1):
    for(r2 = r1 → m − 1):
        set = (ϕ)^TreeSet, sum = 0 ⋆ set: store the presum in ascending order
        set.add(0)
        int[ ] A = [n]
        ⋆ compress multiple rows into one line
        for(j = 0 → n − 1):
            A[j] = col[j, r2] − col[j, r1] + mat[r1, j]
            sum = sum + A[j]
            ⋆ if there exists ∑_0^k A[k] ≥ sum − k, then there exists ∑_{k+1}^j A[k] ≤ k
            e = s.ceilKey(sum − k)
            if(e ≠ null): result = max(result, sum − e)
            set.add(sum)
return result
```

Follow Up: Max Sum Rectangle

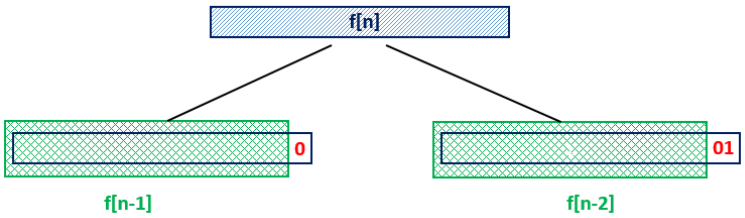
Find a rectangular area whose sum equals s

```
result = 0
for(r1 = 0 → m − 1):
    for(r2 = r1 → m − 1):
        for(j = 0 → n − 1): col_j = a_{r2,j} − a_{r1,j} + matrix_{r1,j}
        result = max(result, maxsubarray(col))
return result
```

600. Non-negative integers without consecutive ones **Pocket Gems**

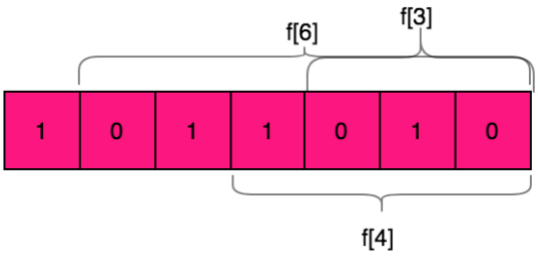
Intuition

Suppose, we need to find the count of binary numbers with n bits such that these numbers don't contain consecutive 1's. In order to do so, we can look at the problem in a recursive fashion. Suppose $f[i]$ gives the count of such binary numbers with i bits. To determine the value of $f[n]$, which is the requirement, we can consider the cases shown below:



From the above figure, we can see that if we know the value of $f[n-1]$ and $f[n-2]$. In order to generate the required binary numbers with n bits, we can append a 0 to all the binary numbers contained in $f[n-1]$ without creating an invalid number. But, we can't append a 1 to all these numbers, since it could lead to the presence of two consecutive ones in the newly generated numbers. Thus, for the currently generated numbers to end with a 1, we need to ensure that the second last position is always 0. Thus, we need to fix a 01 at the end of all the numbers contained in $f[n-2]$. Thus, in total, we get $f[n] = f[n-1] + f[n-2]$

For example, $n = \frac{101100}{543210}(44)$, at the digit of 5,3,2 (d_5, d_3, d_2) they are all 1's. Thus, $result = f_5 + f_3 + f_2$, since (d_3, d_2) are consecutive 1's, so it stops counting at d_2



Intuition & Algorithm

First, calculate the number of integers without consecutive ones in length of n

$$f[n] \coloneqq f[n-1] + f[n-2]$$

Second, for each of bit set to one $bit[i] = 1$, sum all corresponding $f[i]$ up ($re \coloneqq re + f[i]$) until consecutive one's occurs ($bit[i] \coloneqq 1$ & $bit[i-1] \coloneqq 1$).

Finally, if consecutive one's occurs, return $re - 1$

$f[0] = 1, f[1] = 2, f[2] = 3$

$for(i = 3 \to 32): f[i] = f[i-1] + f[i-2]$

$i = 31, re = 0, prevbit = 0$

$while(i \geq 0)$:

    $if\ \Big((num\ \&\ (1 \ll i)) \gg i = 1\Big)$:

        $re \coloneqq re + f[i]$

        $if(prevbit = 1): break$

        $prevbit = 1$

    $else: prevbit = 0$

    $i \coloneqq i - 1$

$return\ re + checkIfExistsConsecutiveOnes(num)$

$int\ checkIfExistsConsecutiveOnes(num)$:

    $preb = 0, le = 32 - int.leadingZeros(num)$

    $i = le - 1$

    $while(i \geq 0)$:

        $if(num\ \&\ (1 \ll i) \neq 0)$:

            $if(preb = 1): return\ 1$

            $preb = 1$

        $else: preb = 0$

        $i \coloneqq i - 1$

    $return\ 0$

---

152. Maximum Product Subarray LinkedIn

$result = A[0]$

$min_{here} = A[0], max_{here} = A[0]$

$for(i = 1 \to len(A) - 1)$:

    $temp = min_{here}$

    $min_{here} = \min(min_{here}, max_{here}, 1) \star A[i]$

$max_{here} = \max(temp, max_{here}, 1) \star A[i]$

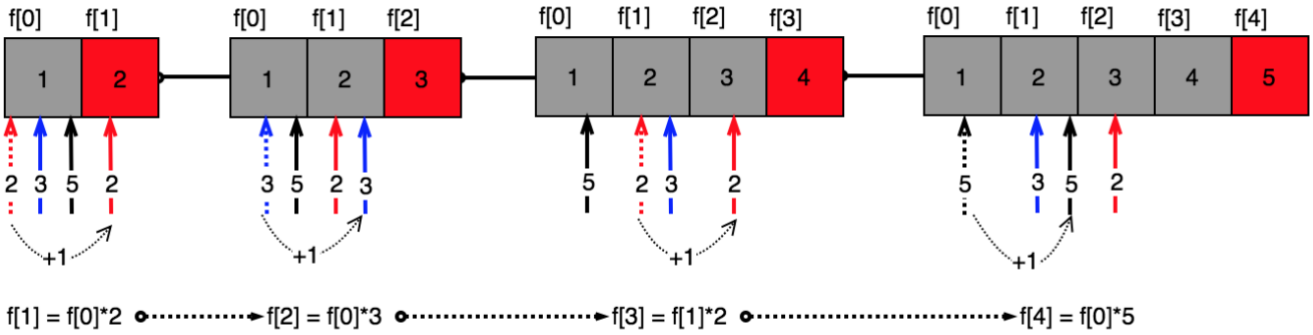
$re = \max(max_{here}, re)$

---

313. Super Ugly Number

264. Ugly Number I

263. Ugly Number II



$for(i = 0 \rightarrow len(primes) - 1)$:

$prime2index[primes[i]] := 0$

$int[\,]\, f = [n + 1], f[0] = 1$

$for(i = 1; i < n)$:

$minv = 2^{31} - 1, minp = -1$

$for(p = 0 \rightarrow len(primes) - 1)$:

$if\ (f\ [prime2index[primes[p]]] \star primes[p] > min)$:

$minv = f\ [prime2index[primes[p]]] \star primes[p], minp = p$

$f[i] = minv$

$prime2index[primes[minp]] := prime2index[primes[minp]] + 1$

$for(p = 0 \rightarrow len(primes) - 1)$:

$if\ (minp \neq p\ \&\ f\ [prime2index[primes[p]]]\ \star p = minv)$:

$prime2index[primes[p]] := prime2index[primes[p]] + 1$

---

91. Decode Ways Facebook Microsoft Uber

$f_i = f_{i-1} + f_{i-2}\ (if\ s_i, s_{i-1}\ can\ form\ a\ number \in [1{,}26])$

$f_i = f_{i-1}$

---

338. Counting Bits

$f[i] = f[i \gg 1] + (i \,\&\, 1)$

329. Longest Increasing Path in a Matrix Google

$f[i,j] = \max(f[i-1,j], f[i,j-1], f[i+1,j], f[i,j+1]) + 1$

241. Different Ways to Add Parentheses

Given a string of numbers and operators, return all possible results from computing all the different possible ways to group numbers and operators. The valid operators are $+, -, \star$.

Tree Set & Tries & Linked List

456. 132 Pattern

$lmin_i = \min(lmin_{i-1}, \mathcal{A}[i])$:

$for(i = n-1 \to 0)$:

    $\not{j} = set.lower(\mathcal{A}[i])$ $\star$ *find the largest value that is smaller than* $a[i]$

    $rmin_i := \not{j} = nil \to \mathcal{A}[i], \not{j}$

    $set.add(\mathcal{A}[i])$

$for(i = 1; i \leq n-2;)$:

    $if(lmin_i < rmin_i < \mathcal{A}[i])$: $return\ true$

$return\ false$

Breaking Bad Uber

Given a list of words $word \cdot list$, and a string $name$, wrap all substring of $name$ which show up in $word \cdot list$ with $'['$ & $']'$, and capitalize the first letter of such substring. For example,

$word \cdot list = \{'apple', 'bce', 'bcd', 'e', 'app'\}$

$name = iloveapple,$

$namw_{new} = ilov[E][Apple]$

(note: both $name_{5,7} = 'app'$ & $name_{5,9} = 'apple'$ show up in the $word \cdot list$. It should choose the longer one $name_{5,9} = 'apple'$ to wrap out.

https://drive.google.com/open?id=1QdTRFv-RNSd3CypcFNz1s7fYdOtGQuPV

421. Maximum XOR of Two Numbers in an Array

```
for(int x: nums):
    result = max{result, x ⊕ most · different(x)}
most · different(TrieNode root, x):
    TrieNode p = o, x = 0
    for(i = 31 → 0):
        mask = 1 ≪ i
        b = (x & mask) ≫ i
        if(p.next[1 − b] ≠ null):
            x = x ∗ 2 + (1 − b)
            p = p.next[1 − b]
        else:
            x = x ∗ 2 + b
            p = p.next[b]
return x
```

211. Add & Search Word (Single word)

212. Add & Search Word II (Multiple words) Google Airbnb Microsoft

```
for(i = 0 → A.length − 1):
    for(j = 0 → A[0].length − 1):
        if(R.next[A[i, j] − a] ≠ nil):
            used[i, j] ≔ True
            s ≔ ""
            dfs(A, i, j, R.next[A[i, j] − a], used, s + A[i, j])
            used[i, j] ≔ False

void DFS(A, i, j, p, used, s):
    if(p.isword):
        re.add(s)
        ⋆ DO NOT return here
    for((nx, ny) ∈ (i, j).next):
        index ≔ A[n_x, n_y] − a
        if(p.next[index] ≠ nil & used[n_x ⋆ n + n_y] = nil):
```

$used[n_x, n_y] \coloneqq True$

$\mathcal{DFS}(A, n_x, n_y, p.next[index], used, s + A[n_x, n_y])$

$used[n_x, n_y] \coloneqq False$

---

327. Count of Range Sum

Solution: use variable sum to keep track the prefix sum so far, use TreeMap to store it.

$$sum = \sum_{0}^{i} nums_i$$

if a subarray $nums[i:j]\ s.t. \sum_i^j nums_k \in [lower, uppper]$, then there must exists a prefix sum:

$$prefix \cdot sum = \left[\sum_{0}^{i} nums_i - upper, \sum_{0}^{i} nums_i - lower\right]$$

$int\ countRangeSum(nums_{(array)}, lower_{(int)}, upper_{int})$:

$if(nums = null\ ||\ nums.length = 0): return\ 0$

$n = nums.length$

$result = 0, sum_{long} = 0$

$SortedMap\langle Long, Integer\rangle\ smap = null$

$TreeMap\langle Long, Integer\rangle\ mp$

$for(int\ x: nums)$:

$sum \leftarrow sum + x$

$sortedmp \leftarrow mp.subMap(sum - upper, sum - lower, true)$

$for(int\ e: sortedmp.values): result \coloneqq result + e$

$mp[sum] \coloneqq mp[sum] + 1$

$return\ result$

---

24. Swap Nodes in Pairs

25. Reverse Nodes in k-group Facebook Microsoft

Each time we find k nodes and reverse the order, then recursively make a call to itself dealing with the remaining nodes.

$ListNode\ reverseKGroup(ListNode\ head, int\ k)$:

$if(head = nil\ or\ k \leq 1): return\ head$

```
cnt = 0, p = head
for(; p ≠ nil & cnt < k; cnt := cnt + 1): p := p.next
⋆ if there are not enough # of nodes within this group, no need for reversing
if(cnt < k): return head
p = head, tail = head, q = p.next, r = nil, rev = 0
for(; rev < k − 1; rev := rev + 1):
    r := q.next
    q.next := p
    p := q
    q := r
ListNode newhead := p
tail.next = reverseKGroup(q, k)
return newhead
```

237. Delete Node in a Linked List Microsoft Apple Adobe

B-Search & Array & Two Pts

48. Rotate image

50. Pow (x, n) Google Facebook Bloomberg LinkedIn

```
double myPow(double x, int n):
    double v := x, re := 1.0, M := Double.MaxValue
    int sign := n < 0 → −1: 1:
    long N := (long)n
    while(N > 0):
        if((N & 1) = 1): re := re ⋆ v
        N >>= 1
        v ⋆= v
    return sign = −1 → 1.0/re : re
```

56. Merge Intervals Google Facebook Microsoft Bloomberg LinkedIn Twitter Yelp

Given a collection of intervals, merge all overlapping intervals.

$\mathcal{N} \coloneqq len(intervals)$

$if(\mathcal{N} = 0): return\ [\phi]$

$if(\mathcal{N} = 1): return\ [intervals[0]]$

$\mathcal{I}nterval\ prev \coloneqq intervals[0]$

$for(i = 1 \to \mathcal{N} - 1):$

    $current \coloneqq intervals[i]$

    $if(prev.end \geq current.start): prev.end = \max(prev.end, current.end)$

    $else: re.add(prev), prev \coloneqq current$

$re.add(prev)$

$return\ re$

Follow Up: Merge Two Sorted Interval List /

Collect All Intersection of Two Sorted Interval List

Intuition & Algorithm

Like Merge Two Sorted Arrays

153. Find Minimum in Rotated Sorted Array Facebook

$l = 0, r = n - 1$

$while(l < r):$

    $mid = \frac{l+r}{2}$

    $if(a[mid] = a[r]): r \coloneqq r - 1$

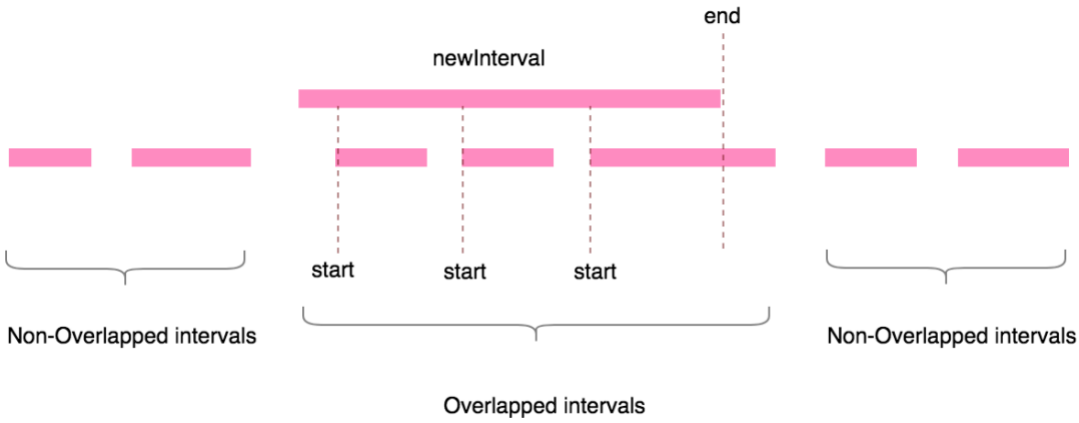
    $elif(a[mid] > a[r]): l \coloneqq mid + 1$

    $elif(a[mid] < a[r]): r = mid$

$return\ a_l$

---

57. Insert Interval Google LinkedIn Facebook



Intuition & Algorithm

First, scan those non-overlapped intervals. Second, scan those overlapped intervals, Third, scan the remained intervals.

$List[Interval]\ insert(List[Interval]\ A, Interval\ new)$:

    $n \coloneqq len(A)$

    $List[Interval]\ re \coloneqq [\phi]$

    $if(n = 0): re.add(new), return\ re$

    $index \coloneqq 0$

    $while(index < n\ \&\ A[index].end < new.start): re.add(A[index{+}{+}])$

    $while(index < n\ \&\ new.end \geq A[index].start)$:

        $new = (\min(A[index].start, new.start), \max(A[index].end, new.end))$

        $index \coloneqq index + 1$

    $re.add(new)$

    $while(index < n): re.add(A[index{+}{+}])$

    $return\ re$

---

154. Find Minimum in Rotated Sorted Array II

$l = 0, r = n - 1$

$while(l < r)$:

    $mid = \frac{l+r}{2}$

    $if(a[mid] = a[r]): r \coloneqq r - 1$

    $elif(a[mid] > a[r]): l \coloneqq mid + 1$

    $elif(a[mid] < a[r]): r = mid$

$return\ a_l$

---

461. Hamming Distance Facebook

$int\ hammingDistance(x, y)$:

$re \coloneqq 0$

$for(d = 31 \to 0)$

$mask \coloneqq (1 \ll d)$

$dx, dy \coloneqq \big((x\ \&\ mask) \gg d\big), \big((y\ \&\ mask) \gg d\big)$

$if(dx \neq dy)$: $re \coloneqq re + 1$

$return\ re$

---

477. Total Hamming Distance Facebook

Say for any particular bit position, count the number of elements with this bit **ON**. (i.e. this particular bit is 1). Let this count be k. Hence the number of elements with this bit **OFF** (i.e. 0) is $(n - k)$ in an n element array). Thus, at this bit, the total hamming distance is: $k \star (n - k)$

$int\ totalHammingDistance(int[\ ]\ A)$:

$re \coloneqq 0$

$bits \coloneqq [32]$

$for(d = 31 \to 0)$:

$mask \coloneqq (1 \ll d)$

$for(i = 0 \to len(A) - 1)$:

$da_i \coloneqq \big((A[i]\ \&\ mask) \gg d\big)$

$bits[d] \coloneqq bits[d] + da_i$

$re \coloneqq re + bits[da_i] \star (len(A) - bits[da_i])$

$return\ re$

---

277. Find the Celebrity

Intuition & Algorithm

Apply two pointers solver, since the celebrity doesn't know anyone else in the party, and the other guys are not known for the celebrity.

$l = 0, r = n - 1$

$while(l \leq r)$:

$if(l\ knows\ r): l = l + 1\ (because\ celebrity\ knows\ nobody)$

$elif(l\ doen't\ know\ r): r = r - 1 (because\ celebrity\ should\ be\ known\ by\ everyone)$

$check\ if\ l\ is\ the\ celebrity\ again$

---

554. Brick Wall Facebook

There is a brick wall in front of you. The wall is rectangular and has several rows of bricks. The bricks have the same height but different width. You want to draw a vertical line from the top to the bottom and cross the least bricks. If your line go through the edge of a brick, then the brick is not considered as crossed. You need to find out how to draw the line to cross the least bricks and return the number of crossed bricks.

Intuition & Algorithm

Find the position where the most of bricks' edges occurs.

$int\ leastBricks(List[List[int]]\ wall)$:

    $most \coloneqq 0$

    $map \coloneqq \{int \Rightarrow int\}$

    $for(List[int]\ \ell ine: bricks)$:

        $pos \coloneqq 0$

        $for(i = 0 \rightarrow len(\ell ine) - 1)$:

            $pos \coloneqq pos + \ell ine[i]$

            $map[pos] \coloneqq map[pos] + 1$

            $most \coloneqq \max(most, map[pos])$

    $return\ len(wall) - most$

---

287. Find the Duplicate Number Google

All number in an array of size $n + 1$ are in the range of $[1: n]$

Solution: slow, fast pointers.

To be noticed, the array companied with such properties forms a cycle if a graph is drawn with index and its corresponding value, for example, an array like $n = 5, [5,5,4,3,1,2], len = 5 + 1, \forall a_i \in [1,5]$, a circle exists in the path by starting with index $0 \rightarrow 5 \rightarrow 2 \rightarrow 4 \rightarrow 1 \rightarrow (5)$.

$slow = 0, fast = 0$

do

$slow = nums[slow]$

$fast = nums[nums[fast]]$

$while(slow \neq fast)$:

$begin = 0$

$while(begin \neq slow)$:

$begin = nums[begin]$

$slow = nums[slow]$

$return\ begin$

Solution 2: negatives flag

$for(i = 0 \rightarrow n - 1)$

$index = abs(nums[i]) - 1$

$if(nums[index] > 0): nums[index] *= -1$

$else: return\ index + 1$

$return\ 0$

Closet & farthest Pair in 2 Sorted Arrays

$l = 0, r = 0, dif = 2^{31} - 1$

$while(l < a.length\ \&\ r < b.length)$

$if(abs(a_l - b_r) < dif): dif = |a_l - b_r|$

$if(a_l \leq b_r): l = l + 1$

$else: r = r + 1$

$return\ dif$

Farthest

$l = 0, r = 0, dif = -2^{32}$

$while(l < a.length\ \&\ r < b.length)$

$if(abs(a_l - b_r) > dif): dif = |a_l - b_r|$

$if(a_l \geq b_r): l = l + 1$

$else: r = r + 1$

$return\ dif$

---

350. Intersection of Two arrays

Solution: like merge sort

Follow Up: one array, say $array_2$ is too large to fit into memory.

Solution: read $array1$ into memory using hash-set, and read $array2$ chunk by chunk into memory, and then find the intersection.

Follow Up: both two arrays are too large to fit into memory.

Solution: using external sort against two arrays (on disk), and each time read top 2 elements from 2 arrays.

75. Sort Colors Uber Didi Labs

$for(int\ x: A)$:

$if(x = 0): A[p_2{+}{+}] = 2, A[p_1{+}{+}] = 1, A[p_0{+}{+}] = 0$

$elif(x = 1): A[p_2{+}{+}] = 2, A[p_1{+}{+}] = 1$

$else: A[p_2{+}{+}] = 2$

Time Complexity: suppose $N(x = 0) = N(x = 1) = N(x = 2) = \frac{N}{3}$

, thus, the total amount of operations will be $\frac{N}{3} * 3 + \frac{N}{3} * 2 + \frac{N}{3} = 2 * N$

Another Solution: use 3 delimiters: l, mid, r,

$[0 \xrightarrow{0} (l-1)];\ [l \xrightarrow{1} (mid-1)];\ [mid \xrightarrow{unknown} (r-1)];\ [r \xrightarrow{2} (n-1)]$

$while(mid \le r)$

$if(A[mid] = 0): swap(A[mid{+}{+}], A[l{+}{+}])$

$elif(A[mid] = 1): mid \coloneqq mid + 1$

$else: swap(A[r{-}{-}], A[mid])$

---

283. Move Zeros Facebook Bloomberg

Given an array $\mathcal{A}$, write a function to move all 0's to the end of it while maintaining the relative order of the non-zero elements.

Intuition & Algorithm

$void\ moveZeros(int[\ ]\ \mathcal{A})$:

    $int\ wall \coloneqq 0$:

    $for(i = 0 \to len(\mathcal{A}) - 1)$:

        $if(\mathcal{A}[i] \neq 0)$: $swap(\mathcal{A}, i, wall), wall \coloneqq wall + 1$

---

260. Single Number III

There are only 2 numbers show up only once, while the remaining numbers show up twice.

Intuition & Algorithm

$\oplus$ all numbers, suppose there two distinct number are $x\ and\ y$, then after $\oplus$ all numbers, it gives out $mask = x \oplus y$. Since $x \neq y$, we can make use of the trick $e \oplus \sim(e - 1)$ which gives the right-most bit set to be "1".so one of them say $x, s.t\ (x \oplus mask) > 0$, and $(y \oplus mask) < 0$. For all the other numbers except (x, y), we can use $mask \oplus nums_i >^{?} 0$ to exactly divide those number into two independent groups.

So, in group I, all elements $nums[i], (\mathcal{A}[i] \oplus mask) > 0$, while in group II, all elements $\mathcal{A}[j], (\mathcal{A}[j] \oplus mask) < 0$. Also, since each number except x occur twice in the group, we can do XOR again inside the group, and the result just gives out the first single number x, and the same thing happen in the second group.

$xor = nums[0]$

$for(i = 1 \to \mathcal{A}.length - 1): xor = xor \oplus \mathcal{A}[i]$

$bit = xor \oplus \sim(xor - 1)$

$rs_0 = 0, rs_1 = 0$

$for(int\ x: \mathcal{A})$:

    $if\big((x\&bit) > 0\big): rs_0 = rs_0 \oplus x$

    $else: rs_1 = rs_1 \oplus x$

$return\ (rs_0, rs_1)$

---

268. Missing Number

Solution I: XOR

$e_1 = 1 \oplus 2 \oplus \cdots \oplus n$

$e_2 = a_0 \oplus a_1 \oplus \cdots \oplus a_{n-1}$

$result = e_1 \oplus e_2$

Solution II: Sum

$$result = \frac{n * (n+1)}{2} - \sum_{0}^{n-1} a[i]$$

Find Popular Element in an Array

$$popular = frequency(x) \geq \frac{n}{2}$$

190. Reverse Bits

For example, $1010000 \rightarrow 0000101$

$for(i = 0 \rightarrow 31)$:

    $mask = 1 \ll i$

    $d = (n \,\&\, mask) \gg i$

    $result = result * 2 + d$

$return\ result$

Follow Up: $popular = frequency(x) \geq \frac{n}{4}$

$$if\left(count\left(A\left[\frac{n}{4}\right]\right) > \frac{n}{4}\right) : return\ A\left[\frac{n}{4}\right]$$

$$if\left(count\left(A\left[\frac{n}{2}\right]\right) > \frac{n}{4}\right) : return\ A\left[\frac{n}{2}\right]$$

$$if\left(count\left(A\left[\frac{3n}{4}\right]\right) > \frac{n}{4}\right) : return\ A\left[\frac{3n}{4}\right]$$

Find lower or upper bound of searched item in sorted array

$int\ upper \cdot bound(target, A)$:

    $l = 0, r = len(A) - 1, ub = -1$

    $while(l \leq r)$:

$mid = \frac{l+r}{2}$

$if(A[mid] = target)$:

$ub = mid, l = mid + 1$

$elif(A[mid] > target): r = mid - 1$

$else: l = mid + 1$

$return\ ub$

Interview Q. Rotate Array Clock wisely in Place VMware

$reverse(arr, 0, n-1)$:

$reverse(arr, 0, k-1)$

$reverse(arr, k, n-1)$

---

231. Power of Two

$return\ x\ \&\ (x-1) = 0$

136. Single Number

$re = a_0 \oplus a_1 \oplus \cdots a_{n-1}$

137. Single Number II

All numbers show up 3 times while only one number which shows up only once

---

$for(i = 31 \to 0)$:

$mask = 1 \ll i, d = 0$

$for(j = 0 \to len(A) - 1)$:

$d \coloneqq d + \big((A[j]\ \&\ mask) \gg i\big)$

$d \coloneqq mod(d, 3)$

$result \coloneqq result \star 2 + d$

---

209. Minimum Size Subarray Sum Facebook

All integers in array are positives, find $sum[l:r] \geq target$

Intuition & Algorithm

Apply two pointers, and always maintain the window sum no exceeds target. When window sum exceeds or equals to target, try to minimize the window size by moving the left pointer.

$int\ minSubArray(\mathcal{S}, A)$:

$l = 0, r = 0, minL = 2^{31} - 1, cur = 0, re \coloneqq null$

$for(; r \leq n - 1)$

$cur \coloneqq cur + A[r]$

$while(l \leq r\ \&\ cur \geq \mathcal{S})$:

$if(cur - A[l] \geq \mathcal{S})$: $cur \coloneqq cur - A[l]$

$else$: $break$

$if(cur \geq \mathcal{S})$: $re = (re = nil) \rightarrow (r - l + 1)$: $\min(re, r - l + 1)$

$return\ re = nil \rightarrow 0: re$

Follow Up: Integers are not all positive.

Intuition & Algorithm

Hash Map

413. Arithmetic Slices

$i = 0, counter = 0$

$while(i < n - 1)$:

$j = i + 1$

$while\big(j < n - 1\ \&\ A_{j+1} - A_j == A_{i+1} - A_i\big)$: $j \coloneqq j + 1$

$le = j - i + 1$

$counter\ += (le - 1) * (le - 2)/2$:

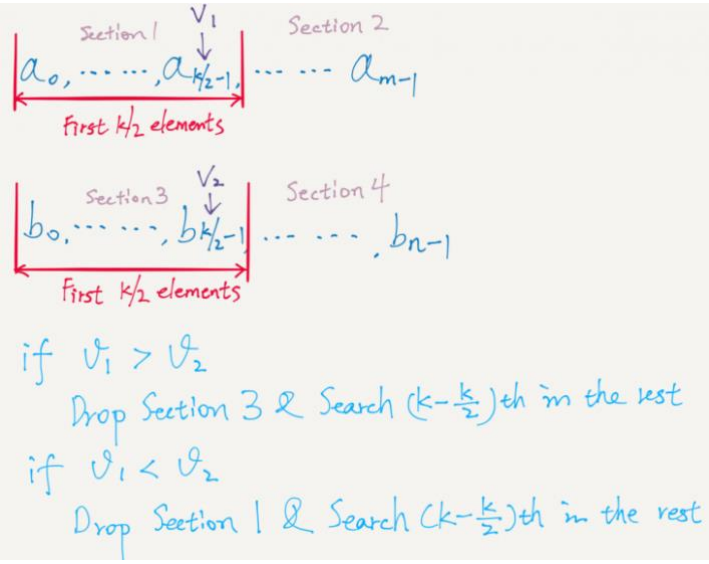
$i = j$

$return\ counter$

---

4. Median of Two Sorted Arrays

Google **Amazon** **Microsoft** **Apple** **Zenefits** **Yahoo** **Adobe** **Dropbox**



Intuition & Algorithm

Compare the two middle elements of A & B, then drop the smaller half.

$find(A, i, B, j, k)$:

$\star$ *if one of them is empty, return the* k^{th} *element of another*

$if\big(i \geq len(A)\big): return\ B[j + k - 1]$

$if\big(j \geq len(B)\big): return\ A[i + k - 1]$

$\star$ *in case* $k = 1$, *return the minimum of two arrays*

$if(k = 1): return \min(A[i], B[j])$

$int\ midA = i + \frac{k}{2} - 1 < len(A) \rightarrow A\left[i + \frac{k}{2} - 1\right]: \infty$

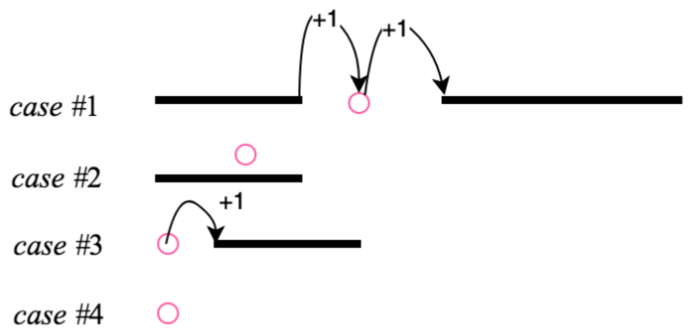
$int\ midB = j + \frac{k}{2} - 1 < len(B) \rightarrow B\left[j + \frac{k}{2} - 1\right]: \infty$

$if(midA < midB): return\ find\left(A, i + \frac{k}{2}, B, j, k - \frac{k}{2}\right)$

$else: return\ find\left(A, i, B, j + \frac{k}{2}, k - \frac{k}{2}\right)$

---

352. Data Stream as Disjoint Intervals



$map[start] \Rightarrow [start, end]$

$addNum(int\ val):$

    $if\,(map[val] \neq nil): return$

    $l \coloneqq map.lowerKey(val)$

    $r \coloneqq map.higherKey(val)$

    $if\,(l \neq null\ \&\ r \neq null\ \&\ map[l].end + 1 = val\ \&\ val + 1 = map[r].start)$

        $map[l].end = map[r].end$

        $map[r] = nil \star remove\ this\ interval\ (very\ important)$

    $elif\,(l \neq null\ \&\ val \leq map[l].end + 1):$

        $map[l].end = \max(map[l].end, val)$

    $elif\,(r \neq null\ \&\ val = map[r].start - 1):$

        $map[val] = map[r].end$

        $map[r] = nil$

    $else: map[val] = [val, val]$

348. Design Tic-Tac-Toe Google Microsoft

Two players play on a $n \star n$ grid, and the diagram below suggests X wins

$$\begin{matrix} X & \blacksquare & \blacksquare \\ \blacksquare & \blacksquare & \blacksquare \\ \blacksquare & \blacksquare & \blacksquare \end{matrix} \rightarrow \begin{matrix} X & \blacksquare & O \\ \blacksquare & \blacksquare & \blacksquare \\ \blacksquare & \blacksquare & \blacksquare \end{matrix} \rightarrow \begin{matrix} X & \blacksquare & O \\ \blacksquare & \blacksquare & \blacksquare \\ \blacksquare & \blacksquare & X \end{matrix} \rightarrow \begin{matrix} X & \blacksquare & O \\ \blacksquare & O & \blacksquare \\ \blacksquare & \blacksquare & X \end{matrix} \rightarrow \begin{matrix} X & \blacksquare & O \\ \blacksquare & O & \blacksquare \\ X & \blacksquare & X \end{matrix} \rightarrow \begin{matrix} X & \blacksquare & O \\ O & O & \blacksquare \\ X & \blacksquare & X \end{matrix} \rightarrow \begin{matrix} X & \blacksquare & O \\ O & O & \blacksquare \\ X & X & X \end{matrix}$$

Algorithm

$int\ row: [2 \star n], column: [2 \star n], diag: [2], xdiag: [2]$

$when\ place(x, y)\ is\ held\ by\ play\ i \in [0,1]:$

    $row[i, x] = row[i, x] + 1$

    $column[i, y] = column[i, y] + 1$

    $if\,(x = y): diag[i] = diag[i] + 1$

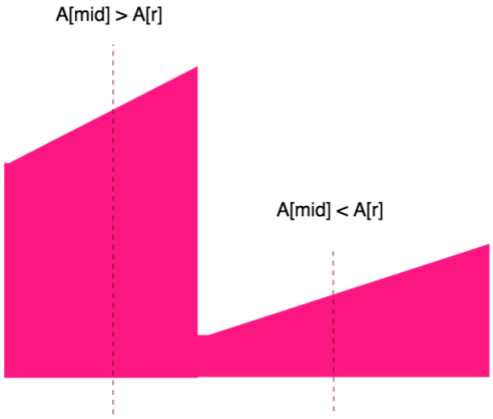
$if(x + y = n - 1): xdiag[i] = xdiag[i] + 1$

$if(row[i, x] = n\ or\ column[i, y] = n\ \&\ diag[i] = n\ \&\ xdiag[i] = n): return$ win

---

33. Search in Rotated Sorted Array

Suppose an array sorted in ascending order is rotated at some pivot unknown to you beforehand. (i.e., [0,1,2,4,5,6,7] might become [4,5,6,7,0,1,2]). You are given a target value to search. If found in the array return its index, otherwise return -1. You may assume no duplicate exists in the array.



Intuition & Algorithm

$int\ search(int[\ ]\ A, int\ target)$:

$n \coloneqq len(A)$

$if(n = 0): return - 1$

$l \coloneqq 0, r \coloneqq n - 1$

$l = 0, r = len(A) - 1$

$for(; l \leq r;)$:

$mid \coloneqq \frac{l+r}{2}$

$if(A[mid] = target): return\ mid$

$if(A[mid] < A[r]):$ ⋆ *case #1*

$if(A[mid] < target\ \&\ target \leq A[r]): l \coloneqq mid + 1$

$else: r \coloneqq mid - 1$

$elif(A[mid] > A[r]):$ ⋆ *case #2*

$if(A[l] \leq target\ \&\ target < A[mid]): r \coloneqq mid - 1$

$else: l \coloneqq mid + 1$

```
        else: r := r − 1
    return l
```

34. Search for a Range

Search for the lower & upper boundary of given value

```
int[ ] search · range(int[] A, int target):
    lb ← lower · boudnary(A, target)
    rb ← upper · boudnary(A, target)
    return new int[] {lb, rb}

int lower · boudnary(A, target)
    l = 0, r = len(A) − 1, lb = −1
    while(l < r):
        mid = (l+r)/2
        if(A[mid] = target): lb = mid, r := r − 1
        elif(A[mid] < target): l := mid + 1
        else: r = mid − 1
```

35. Search insert position

```
l = 0, r = len(A) − 1
while(l < r):
    mid = (l+r)/2
    if(target ≤ A[mid]): r = mid
    else: l = mid + 1
return l
```

240. Search a 2D Matrix II Google Apple Amazon

Intuition & Algorithm

Starting searching from the right-upper corner$\big(0, len(mat[0])\big)$

Time Cost: $O(m+n)$

```
r = 0, c = matrix[0].length − 1
```

$while(r < len(mat)\ \&\ c \geq 0)$:

    $if(mat[r,c] = target)$: $return\ true$

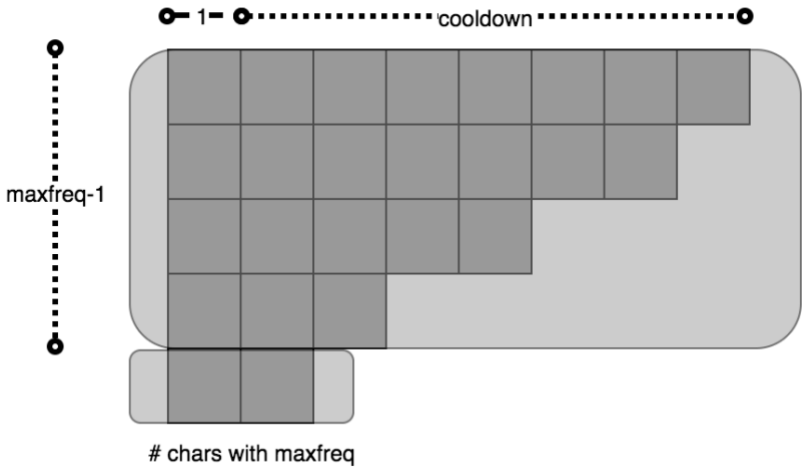
    $elif(target < mat[r,c])$: $c \coloneqq c - 1$

    $else$: $r \coloneqq r + 1$

$return\ false$

---

621. Task Scheduler Facebook



$for\ example, (A_3, B_3, C_2, cooldown = 2) \rightarrow \begin{bmatrix} A & B & C \\ A & B & C \\ A & B & \end{bmatrix}$

Algorithm

$$result = \left(max_{freq} - 1\right) \star (cooldown + 1) + \sum_{i=0}^{25} \left(freq\left[task[i]\right] = maxfreq\right)$$

767. Reorganize String Uber Google

Algorithm #1

priority queue

$$\boxed{node\begin{cases} char \\ freq \end{cases} \rightarrow PriorityQueue(descending\ order\ of\ freq)}$$

Each time take two nodes $first$ & $second$ (if applicable) out of pq.

Then, if $first.freq > 0$ push it back to pq, the same for $second$

Corner case, if one char whose frequency $freq > \frac{(n+1)}{2}, then\ return\ false$

Solution II: count sort, quite like Q. 621

$cell \leftarrow array_{2d}(unique\ char \times max \cdot freq, default = '\#')$

$for(freq = len(str) \rightarrow 1)$:

    $if(map[freq] \neq nil)$:

        $list\langle char\rangle\ ls \leftarrow map[freq]$

        $for(char\ ch\ in\ ls)$:

            $for(i = 0 \rightarrow freq)$: $cell[rowid].add(ch)$

            $rowid += 1$

$i = 0, j = 0$

$for(; j < max \cdot freq;)$:

    $for(; i < rowid;)$:

        $if\big(cell_{i,j} == '\ \#'\big)$: $break$

        $print(cell_{i,j})$

---

3. Longest Substring Without Repeating Characters

$count = \{\phi\}$

$l = 0$

$for(r = 0; r < s.length;)$

    $count[s[r]] := count[s[r]] + 1$

    $while\big(l \leq r\ \&\ count[s[r]] > 1\big)$:

        $counts[s[l--]] -= 1$

    $result = max(result, r - l + 1)$:

$return\ result$

---

389. Find the difference Google

Algorithm

$count = [256]: int$

$for(i = 0; i < s.length;): count[s[i]] := count[s[i]] + 1$

$for(i = 0; i < s.length;): count[s[i]] := count[s[i]] - 1$

$for(c = a \rightarrow z): if(count[c] \neq 0): result = c$

409. Longest Palindrome Google

Given a string which consists of lowercase or uppercase letters, find the length of the longest palindromes that can be built with those letters.

$$result = \sum(x = letter_i.count, x\&1 == 0) + max\{x = letter_i.count, x\&1 == 1\}$$

11. Container with Most Water Bloomberg

Given n vertical lines: $height_0 < height_1 < \cdots height_{n-1}$.

$while(l \le r)$:

  $if\,(height_l \le height_r)$: $result = \max(result, (r-l) \star height_l)\,, l \coloneqq l+1$

  $else$: $result = max\{result, (r-l) * height_r\}, r \coloneqq r-1$

---

15. 3Sum & 18. 4Sum

$Arrays.sort(nums)$

$for(i = 0; i < n-1;)$:

  $l = i+1, j = n-1$

  $while(l < r)$:

    $if\,(a_l + a_r + a_i = target)$:

      $l \coloneqq l+1, r \coloneqq r-1$

      $while(l < r \;\&\; a[l] = a[l-1])$: $l \coloneqq l+1$

      $while(l < r \;\&\; a[r] = a[r+1])$: $r \coloneqq r-1$

    $elif\,(a_i + a_l + a_r > target)$: $r \coloneqq r-1$

    $else$: $l \coloneqq l+1$

---

454. 4Sum II

Solution: hash A + B first, and then check C + D in hash map

26. Remove Duplicates from Sorted Array Facebook Microsoft Bloomberg

---

$wall = 1$

$for(i = 1 \to len(A) - 1)$:

  $if\,(i \ge 1 \;\&\; A[i] \ne A[i-1])$:

    $A[wall{+}{+}] = A[i]$

$return\ wall$

---

27. Remove Element

$wall = 0$

$for(i = 0 \rightarrow len(A) - 1)$:

    $if(A[i] \neq val): A[wall{+}{+}] \coloneqq A[i]$

$return\ wall$

392. Is Subsequence **Uber**

$for(p_s = 0, p_t = 0; p_s < len(s)\ \&\ p_t < len(t);)$:

    $if(s[p_s] = t[p_t]): p_t \mathrel{+}= 1$

    $p_s \mathrel{+}= 1$

$return\ p_t == len(t)$

Follow Up: Check a list of string where $s_{i-1}\ is\ one\ prefix\ of\ s_i$

$for(String\ t: strList)$:

    $for(i = ps, j = pt; i < len(s)\ \&\ j < len(t);)$:

        $if\big(s_i == t_j\big): j \leftarrow j + 1$

        $i \leftarrow i + 1$

    $if\big(j == len(t)\big): ps = i, pt = j$

204. Count Primes

$is \cdot prime[i] \leftarrow false, 0 \leq i \leq n - 1$

$for\big(i = 2; i < \lceil\sqrt{n}\rceil\big);$

    $if(is \cdot prime[i])\ result \mathrel{+}= 1$

    $for(j = i + i; j < n;): is \cdot prime[j] = false$

$return\ result$

451. Sort Characters by Frequency **Bloomberg**

Solution I: Bucket Sort

Time Complexity: $O(n)$, Space Complexity: $O(n)$

$List\langle char\rangle[\,]\ freq = new\ ArrayList[n + 1]$

$map\langle char, int\rangle\ char2freq$

$for(char\ c: str)$:

$counter[c]+= 1$

$for(i = 0; i < 26;)$:

$freq[counter[i]].add((char)i)$

$for(i = n; i \geq 0;)$:

$if(freq[i].notempty)\ result.addAll(freq[i])$

---

692. Top K Frequent Words Amazon Bloomberg Uber Yelp Pocket Gems

Solution: quite like 451

Follow Up: Get K most frequent words from word stream. Bloomberg

The solution above (451) works well when the number of words is not that large, the strategy here is trading time for space. But in many cases, the number of words is very large, say 10^8, while the number of different words is relatively small compare to it, say 10^4, so it is possible to do word count with hash-map, but not possible to allocate such number of buckets for bucket sort. So, an optimized solution is Quick-Select, it takes $\boldsymbol{O(n)}$ time and $\boldsymbol{O(k)}$ **space**, where$n$ is the number of words in text.

$for(word\ w: text): map[w] = map[w] + 1$

$freq_{array,1d} = map.values()$

$k^{th} \cdot freq = quick \cdot select(freq, 0, len(freq) - 1, len(freq) - k)$

$for(Map.Entry\langle word, freq\rangle\ entry: map.entrySet())$:

$if(entry.getValue() \geq k^{th} \cdot freq)$:

$result.add(entry.getKey())$

$if(result.size() = k): break;$

$return\ result$

---

76. Minimum Window Substring &

567. Permutation in String &

438. Find All Anagrams in a String Uber

$minimum \cdot window \cdot substring(s, t)$:

$for(i = 0 \rightarrow len(t) - 1)$:

$need \cdot find[t[i]] \coloneqq need \cdot find[t[i]] + 1$

$l = 0, e = 0$

$for(r = 0; r < s.length;)$:

```
        has · found[s[r]] := has · found[s[r]] + 1;
        if(has · found[s[r]] ≤ need · find[s[r]]): e := e + 1
        if(e = len(target)):
            while(need · find[s[l]] = 0 || has · found[s[l]] > need · find[s[l]]):
                if(has · found[s[l]] > need · find[s[l]]):
                    has · found[s[l]] := has · found[s[l]] − 1
                l := l + 1
    return s_{l,r}
```

138. Copy List with Random Pointer Amazon

```
for(Node nd: list):
    nd · copy ← make · copy(nd)
    map(nd) → nd · copy
for(Node nd: list):
    map[nd].next = map[nd.next]
    map[nd].randomNext = map[nd.randomNext]
```

133. Clone Graph Google Facebook Uber Pocket Gems

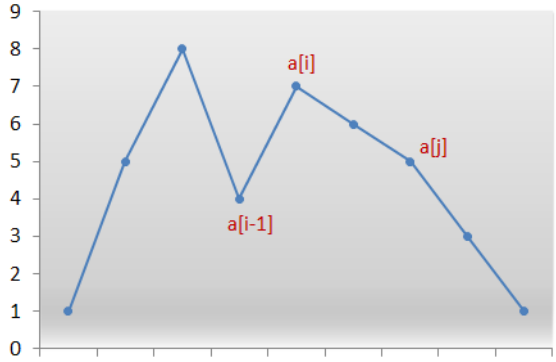
do bfs on graph, and make copy for each of node:

```
for(g: graph.nodes):
    list⟨node⟩ adjs ← g.adjacents
    for(node nd: adjs):
        map[g].adjacentlist.add(map[nd])
```

31. Next Permutation Facebook Google Microsoft Amazon Samsung LinkedIn

Generate next slightly greater number with same digits

Intuition & Algorithm



Find first ℓ s $\mathcal{A}[\ell] < \mathcal{A}[\ell]$ t. from rightmost, then find first r in range of $[\ell + 1, r - 1]$ s.t $\mathcal{A}[\ell] < \mathcal{A}[r]$ from right-most. Next, swap $(\mathcal{A}[\ell], \mathcal{A}[r])$. Finally, sort $\mathcal{A}[l + 1 : n - 1]$

Next Palindromic Number

Consider three conditions:

---

1. $if\ a = [9, 9, \cdots, 9], return\ [1, 0, \cdots, 0, 1]$

2. $else\ if\ a\ is\ palindromic\ except\ for\ case\ 1, increase\ a\left[\frac{n}{2}\right]\ and\ a\left[\frac{n}{2} - 1\right]\ by\ 1$

3. $else, copy\ left\ half\ a\left[0 : \frac{n}{2} - 1\right]\ to\ the\ right\ half\ a\left[\frac{n}{2} : n - 1\right], get\ a^{\times}$

   $if\ a^{\times} < a, then\ a\left[\frac{n}{2}\right] \mathrel{+}= 1, a\left[\frac{n}{2} - 1\right] \mathrel{+}= 1, otherwise, do\ nothing$

---

80. Remove Duplicates from Sorted Array II Facebook

Given a sorted array *nums*, remove the duplicates in-place such that duplicates appeared at most twice and return the new length.

Intuition & Algorithm

$wall = 1, count := 0$

$for (i = 1 \to len(A) - 1)$:

    $count := (A[i] = A[i - 1]) \to count + 1 : 0$

    $if (count < 2)$:

        $A[wall{+}{+}] := A[i]$

$return\ wall$

---

442. Find all Duplicates in an Array Pocket Gems

Intuition & Algorithm

Negative Labeling, since $\mathcal{A}[i] \in [1, n]$, we can label $\mathcal{A}[|\mathcal{A}[i]| - 1] \star= -1$

$re \coloneqq [\phi], n \coloneqq len(A)$

$for(i = 0 \to n - 1)$:

    $int\ index \coloneqq |A[i]| - 1$

    $if(index < n): re.add(index + 1)$

    $else: A[index] \star= -1$

$return\ re$

---

41. First Missing Positive

448. Find All numbers disappeared in an array

Solution: firstly swap all positive integers to the left, for example, $[3,4,-1,1] \to [3,4,1,-1]$, then apply "negative mark" algorithm.

$for(i = 0; i < len(arr) - 1)$:

    $if(arr[i] > 0): arr[le++] = arr[i]$

$for(i = 0 \to le - 1)$:

    $idx = |arr_i| - 1$

    $if(idx < le\ \&\ arr[idx] > 0): arr[idx] \coloneqq arr[idx] \star -1$

$for(i = 0 \to le - 1)$:

    $if(arr[i] > 0): return\ (i + 1)$

Common Chars in n strings

$first = 0$

$for(char\ c: s[0]): first \leftarrow first\ |\ \big(1 \ll (c - a)\big)$

$for(i = 1 \to n - 1)$:

    $second = 0$

    $for(char\ c: s[i]): second \coloneqq second\ |\ \big(1 \ll (c - a)\big)$

    $first = first\ \&\ second$

$for(i = 0 \to 26)$:

$if\ \Big(\big(first\ \&\ (1 \ll i)\big) \gg i == 1\Big) : re \coloneqq re + (char)(i + a)$

---

318. Maximum Product of Word Lengths

Find the maximum value of $length(word[i]) \star length(word[j])$ where the two words do not share common letters.

Intuition & Algorithm

encode string using binary format, like $encode = encode \mid \big(1 \ll (str[i] - 'a')\big), \forall i \in [0, le - 1]$, so checking if two strings share the same characters just need to check $estr[i]\ \&\ estr[j] = 0$ or not (in $O(1)$ time). Thus, the overall time complexity is $O(m * n)$

BT & BST & Iterator

302. Smallest Rectangle Enclosing Black Pixels Google

An image is represented by a binary matrix with 0 as a white pixel and 1 as a black pixel. The black pixels are connected, i.e., there is only one black region. Pixels are connected horizontally and vertically. Given the location (x, y) of one of the black pixels, return the area of the smallest (axis-aligned) rectangle that encloses all black pixels.

Intuition & Algorithm

Apply B-Search to find the left, right, top & bottom boundary of 1.

Time Costs $O(m \star \log(n) + n \star \log(m))$

$int\ minArea(int[\,][\,]\ image, int\ x, int\ y)$:

$top \coloneqq searchVertical(image, 0, x, searchTop = True)$

$bottom \coloneqq searchVertical(image, x, len(image) - 1, searchTop = False)$

$left \coloneqq searchHorizontal(image, 0, y, searchLeft = True)$

$right \coloneqq searchHorizontal(image, y, len(image[0]) - 1, searchLeft = False)$

$return\ (bottom - top + 1) \star (right - left + 1)$

$int\ searchVertical(int[\,][\,]\ image, int\ top, int\ bottom, bool\ searchTop)$:

$re \coloneqq searchTop = True \rightarrow bottom : top$

```
    while(top ≤ bottom):
        mid := (top+bottom)/2
        s := 0
        for(j = 0 → len(image[mid]) − 1): s := s + image[mid, j]
        if(s ≥ 1):
            re := mid
            if(searchTop): bottom := mid − 1
            else: top := mid + 1
        else:
            if(searchTop): top := mid + 1
            else: bottom := mid − 1
    return re
int searchHorizontal(int[ ][ ] image, int left, int right, bool searchLeft):
    re := searchLeft = True → right: left
    while(left ≤ right):
        mid := (left+right)/2
        s := 0
        for(i = 0 → len(image) − 1): s := s + image[i, mid]
        if(s ≥ 1):
            re := mid
            if(searchLeft): right := mid − 1
            else: left := mid + 1
        else:
            if(searchLeft): left := mid + 1
            else: right := mid − 1
    return re
```

---

235. LCA of BST & BT

236. LCA of BT

```
lca · bst(TreeNode o, int lb, int rb):
    if(o = nil): return null
    if(lb ≤ o.val ≤ rb): return o.val
    elif(lb > o.val): return lca · bst(o.right, lb, rb)
    else: return lca · bst(o.left, lb, rb);
```

$lca \cdot bt(TreeNode\ o, TreeNode\ p, TreeNode\ q)$:

$if\ (o\ is\ null)$: $return\ null$

$if\ (o = p)$: $return\ p$

$if\ (o =\ q)$: $return\ q$

$lo \leftarrow lca \cdot bt(o, p, q)$

$ro \leftarrow lca \cdot bt(o, p, q)$

$if\ (lo \neq nil\ \&\ ro \neq nil)$: $return\ o$;

$if\ (lo = nil\ \&\ ro \neq nil)$: $return\ ro$

$if\ (lo \neq nil\ \&\ ro = nil)$: $return\ lo$

$return\ null$

Interview Q. **2nd Largest Element in BST** **NewsOnChat**

Time Complexity: $O(h + k)$,

h: $because\ it\ traverse\ from\ root\ to\ the\ left \cdot most\ item$

k: $because\ it\ won't\ stop\ until\ finding\ the\ k^{st} \cdot item$

$void\ k^{st} \cdot largestItem(TreeNode\ root, Count\ c)$:

$if\ (root == null\ or\ c.val \geq k)$: $return$;

$k^{st} \cdot largestNode(node.right, c)$ ⋆ *count # nodes of right substree*

$c.times = c.times + 1$

$if\ (c.times == k)$:

$print(k^{st} \cdot element\ is\ root.val)$

$return$

$k^{st} \cdot largestNode(root.left, c)$

---

652. Find Duplicate Subtrees **Google**

Solution: Preorder + Hash-map

Since same tree structure correspond to the same preorder serialization. I use a hash-map to map the tree preorder serialization to the occurrence times. Once one serialization shows up 2 or more than twice, I add it to the result.

$String\ serialize(TreeNode\ o, Map_{str \to int}\ map, List\langle TreeNode\rangle\ result)$:

$if\ (o = null)$: $return$ "#"

$se = (o.val) + , + serialize(o.left, map, result) + , +\ serialize(o.right, map, result)$

```
    if(map.getOrDefault(se, 0) == 1): result.add(o)
    map[se] = map[se] + 1
    return se
main():
    serialize(o, map, result)
    return result
```

---

173. Binary Search Tree Iterator Google Facebook Microsoft LinkedIn

Intuition & Algorithm

Can Refer to https://www.geeksforgeeks.org/inorder-tree-traversal-without-recursion/

```
stack(type = TreeNode)
BSTIterator(TreeNode root):
    node = root
    while(node ≠ null):
        stack.push(node)
        node = node.left
boolean hasNext():
    return !stack.isEmpty()
int next():
    node = stack.pop()
    if(node.right ≠ null):
        node = node.right
        while(node ≠ null):
            stack.push(node)
            node = node.left
    return node.val
```

---

98. Validate Binary Search Tree Facebook Microsoft Amazon Bloomberg

---

```
min = −2^31, max = 2^31 − 1
check(TreeNode o, int min, int max):
    if(o = nil): return true
```

```
    if(o.val ∈ [min, max] & check(o.l, min, o.val) & check(o.r, o.val, max))
        return true
    return false
```

99. Recover Binary Search Tree

Two nodes are mistakenly swapped in BST, asked to find them and swap back

```
void recoverTree(TreeNode R):
    prev := nil, 1st = nil, 2nd = nil
    stack := {ϕ}
    TreeNode p := R
    while(p ≠ nil): stack.push(p), p := p.left
    while(stack.size > 0):
        curr := stack.pop
        if(prev ≠ nil & prev.val ≥ curr.val):
            if(1st ≠ nil): 1st = prev
            2nd = curr
        prev := curr
        if(curr.right ≠ nil):
            r := curr.right
            while(r ≠ nil): stack.push(r), r := r.left
    swap(1st, 2nd)
```

285. In-order Successor in BST Facebook Microsoft Pocket Gems

```
TreeNode suc := nil
while(root ≠ nil):
    if(p.val ≥ root.val): root := root.right
    else: suc = root, root := root.left
return suc
```

572. Subtree of Another Tree Facebook eBay

Given two non-empty binary trees s and t, check whether tree t has exactly the same structure and node values with a subtree of s

Intuition & Algorithm #1

Two BTs has the same structure & node values **if & only-if** two BTs share the same pre-order serialized representation.

Time Costs: $O(m^2 + n^2 + m \star n), m = size(s), n = size(t)$

Intuition & Algorithm #2

For each of node in tree s, check if every subtree is the same as t.

Time Costs: $O(m \star n), m = size(s), n = size(t)$

145. Binary Tree Post-Order Traversal

Intuition & Algorithm

$s_1 := \{\phi\}, s_2 := \{\phi\}$

$s_1.push(root)$

$while(s_1.size > 0)$:

    $Node\ node := s_1.pop$

    $s_2.push(node)$

    $if(node.left \neq nil): s_1.push(node.left)$

    $if(node.right \neq nil): s_1.push(node.right)$

$Postorder := s_2.top \rightarrow s_2.bottom$

---

199. Binary Tree Right Side View NewsOnChat

$rightView = \{\phi\}$

$Q = \{root\}$

$while(Q\ isn't\ empty)$:

    $n = Q.size$

    $for(i = 0 \rightarrow n - 1)$:

        $node = Q.poll()$

        $if(i = n - 1): rightView.offer(node.val)$

        $if(node.left \neq null): Q.offer(node.left)$

        $if(node.right \neq null): Q.offer(node.right)$

$return\ rightView$

---

226. Invert Binary Tree

Solution: reverse left-sub tree & right-sub tree first, then swap left & right pointer.

```
invert(TreeNode o):
    if (o is null): return null
    TreeNode lc ← invert(o.left)
    TreeNode rc ← invert(o.right)
    temp ← o.left
    o.left ← o.right
    o.right ← temp
    return o
```

100. Same Tree

```
same(TreeNode p, TreeNode q):
    if (p = null): return q = null
    if (p.val = q.val & same(p.left, q.left) & same(p.right, q.right)):
        return true
    return false
```

101. Symmetric Tree

```
symmetric(TreeNode p, TreeNode q):
    if (p = null): return q = null
    if (q = null): return p = null
    if (p.val = q.val & symmetric(p.l, q.r)& symmetric(p.r, q.l)):
        return true
    return false
```

297. Serialize & De-serialize BT

Google **Facebook** **Microsoft** **Amazon** **Bloomberg** **Uber** **LinkedIn** **Yahoo**

Solution: preorder

Time Complexity: $O(n)$, Space Cost: $16 \star 2n = 32n\ bits$, there are $2n$ nodes(including null node), each node takes 16 $bits$ for storage.

$void\ serialize(TreeNode\ root, StringBuffer\ sb)$

$if\ (root\ is\ nil)$: $sb.append(\#), return;$

$sb.append(root.val + ",")$

$serialize(root.left, sb)$

$serialize(root.right, sb)$

$Treeode\ de \cdot serialize(list\langle str\rangle\ nodes)$

$if\ (nodes.empty\ ||\ nodes.peek ==' \#'):$

$if\ (nodes.not \cdot empty)$: $nodes.pollFirst$

$return\ null$

$TreeNode\ root \leftarrow new\ TreeNode\big(int(nodes.pollFirst)\big)$

$root.left \leftarrow de \cdot serialize(nodes)$

$root.right \leftarrow de \cdot serialize(nodes)$

$return\ root$

Follow Up: Succinct serialization & de-serialization **Google**

Use two lists, one is called structure, another is called data, both are stored in pre-order.

$void\ serialize(root, structure: list, data: list)$

$if\ (root\ is\ nil)$:

$structure.add(0), return$

$structure.add(1)$

$data.add(root.val)$

$serialize(root.left, structure, data)$

$serialize(root.right, structure, data)$

$Treeode\ de \cdot serialize(structure, data)$:

$if\ (nodes.empty)$: $return\ nil$

$bool\ b = structure.peekFirst$

$if\ (b == 0)$: $structure.pollFirst$

$else$:

$TreeNode\ root \leftarrow new\ TreeNode\big(int(data.pollFirst)\big)$

$root.left \leftarrow de \cdot serialize(structure, data)$

$root.right \leftarrow de \cdot serialize(structure, data)$

$return\ root$

$return\ null$

---

102. Binary Tree Level Order Traversal & II (107)

103. Binary Tree Zigzag Level Order Traversal

Solution: BFS

144. Binary Tree Preorder Traversal & Post-order (145)

450. Delete Node in BST

$TreeNode\ deleteNode(TreeNode\ o, key)$:

$if(o\ is\ null): return\ null$

$o.left = deleteNode(o.left, key)$

$o.right = deleteNode(o.right, key)$

$if(o.val \neq key): return\ o$

$else$:

$p = o.right;$

$if(p\ is\ null): return\ o.left$

$while(p.left\ is\ not\ null): p = p.left$

$swap(p, o)$

$o.right = deleteNode(o.right, key)$

$return\ o$

---

104. Maximum Depth of Binary Tree

Solution: $depth(o) = max\ \{depth(o.left), depth(o.right)\} + 1$

110. Balanced BT Bloomberg

$depth(TreeNode\ o)$:

$if(o\ is\ null): return\ 0$

$lheight \coloneqq depth(o.left)$

$rheight \coloneqq depth(o.right)$

$if(lheight = -1\ or\ rheight = -1\ or\ abs(lheight - rheight) > 1)$:

$return -1$

$return \max(lheight, rheight) + 1$

$balanced = depth(o) = -1$

Interview Q. Preorder to BST

$index = 0, min = -2^{31}, max = 2^{31} - 1$

$TreeNode\ pre2BST\big(preorder_{(type=array,1d)}, min, max\big)$:

$if(index > preorder.length)$: $return\ null$

$if(preorder[index] \in [min, max])$:

$root = new\ TreeNode(preorder[index++])$

$root.left = pre2BST(preorder, min, root.val)$

$root.right = pre2BST(preorder, root.val, max)$

$return\ root$

---

323. Number of Connected Components in an Undirected Graph

Solution: union-find

$CC = N(vertices)$

$for(edge\ e: edges)$:

$o_1 = find(e.from)$

$o_2 = find(e.to)$

$if(o_1 \neq o_2)$:

$union(o_1, o_2)$

$CC = CC - 1$

---

543. Diameter of Binary Tree **Google** **Facebook**

Solution: pre-calculate height for each node in BT, then store the $(node, height)$ mapping into hash-map, finally calculate the diameter like this:

$$\mathcal{D}(o) = (h[o.left] + h[o.right]), h[nil] \coloneqq 0$$

$$re \coloneqq \max\big(\mathcal{D}(o), \mathcal{D}(o.left), \mathcal{D}(o.right)\big)$$

Longest Path in N_{ary} Tree Jingchi.ai

Solution: pre-calculate height for each node in BT, then store the $(node, height)$ mapping into hash-map, finally

---

$height: map(Node, height)$

$int\ longest \cdot path(Node\ root)$:

    $if(root == null): return\ 0$

    $childNum \leftarrow root.childs.size()$

    $result = 0$

    $for(i = 0 \rightarrow childNum - 1)$:⋆ *find LP in root's subtrees*

        $result = \max(result, longest \cdot path(root.childs[i]))$

    $mx_1 = null, mx_2 = null$

    $for(i = 0 \rightarrow childNum - 1)$:

        $h \leftarrow height[root.childs[i]]$

        $if(mx_1 = null \ ||\ h > mx_1)$:

            $mx_2 = mx_1, mx_1 = h$

        $elif(mx_2 = null \ ||\ h > mx_2)$:

            $mx_2 = h$

    $mx_1 = mx_1 = nil \rightarrow 0: mx_1$

    $mx_2 = mx_2 = nil \rightarrow 0: mx_2$

    $re = \max(re, mx_1 + mx_2 + 1)$

$return\ re$

$int\ depth(Node\ root)$:⋆ $height[root] = \max\big(height\big[child[i]\big]\big) + 1, \forall i \in [0, size(root.childs)]$

    $if(root = null): return\ 0$

    $childNum \leftarrow root.childs.size()$

    $maxh = 0$

    $for(i = 0 \rightarrow childNum - 1)$:

        $h = depth(root.childs[i])$

        $maxh = \max(maxh, h)$

    $height[root] = maxh + 1$

    $return\ maxh + 1$

$main()$:

    $Node\ root = buildTree()$

    $depth(root)$

$result = longest \cdot path(root)$

---

549. Binary Tree Longest Consecutive Sequence II Google

Follow Up: N-ary Tree Longest Consecutive Sequence

$incr: map(Node \Rightarrow length\ of\ longest\ increasing\ consecutive\ sequence\ end\ up\ with\ this\ node)$

$decr: map(Node \Rightarrow length\ of\ longest\ decreasing\ consecutive\ sequence\ end\ up\ with\ this\ node)$

$int\ longest \cdot consecutive \cdot sequence(Node\ root)$:

$if(root == null): return\ 0$

$childNum \leftarrow root.childs.size$

$result = 0$

$for(i = 0 \rightarrow childNum - 1)$:

$result = \max(result, longest \cdot consecutive \cdot sequence(root.childs[i]))$

$maxh_{incr} = null, maxh_{decr} = null$

$for(i = 0 \rightarrow childNum - 1)$:

$if(root.child[i].val + 1 = root.val): h_{incr} := incr[root.childs[i]]$

$if(root.child[i].val - 1 = root.val): h_{decr} := decr[root.childs[i]]$

$if(maxh_{incr} = null \,||\, h_{incr} > maxh_{incr}): maxh_{incr} = h_{incr}$

$if(maxh_{decr} = null \,||\, h_{decr} > maxh_{decr}): maxh_{decr} = h_{decr}$

$maxh_{incr} = (maxh_{incr} = null)?\ 1: maxh_{incr} + 1$

$maxh_{decr} = (maxh_{decr} = null)?\ 0: maxh_{decr} + 1$

$result = \max(result, maxh_{incr} + maxh_{decr} - 1)$

$return\ result$

$int\ getIncrDepth(Node\ root)$:

$if(root == null): return\ 0$

$childNum \leftarrow root.childs.size$

$maxh_{incr} = 0$

$for(i = 0 \rightarrow childNum - 1)$:

$h = getIncrDepth(root.childs[i])$

$if(root.child[i].val + 1 == root.val): maxh_{incr} = \max(maxh_{incr}, h)$

$incr[root] = maxh_{incr} + 1$

$return\ maxh_{incr} + 1$

$int\ getDecrDepth(Node\ root)$:

$if(root == null): return\ 0$

$childNum \leftarrow root.childs.size$

$maxh_{decr} = 0$

$for(i = 0 \rightarrow childNum - 1)$:

$h = getDecrDepth(root.childs[i])$

$if(root.child[i].val + 1 == root.val): maxh_{decr} \leftarrow \max(maxh_{decr}, h)$

$decr[root] = maxh_{decr} + 1$

$return\ maxh_{decr} + 1$

Largest Complete Tree ForUsAll

$the\ height\ of\ complete\ tree\ is: h =$ **min**$\big(height(o.l), height(o.r)\big) + 1$, to be noticed, it takes the minimal one of left subtree & right subtree plus 1 as its complete tree height, which is different than our node's height computation where $node's\ height\ = max(lh, rh)\ + 1$

$the\ amount\ of\ nodes\ in\ complete\ tree\ with\ height\ h\ is: size = 1 \ll h - 1$

$height \cdot complete(Node\ o)$:

$if(o\ is\ null): return\ 0$

$lh = height \cdot complete(o.left)$

$rh = height \cdot complete(o.right)$

$h \cdot complete = min(lh, rh) + 1$

$result = max(result, h \cdot complete)$

$return\ h \cdot complete$

$size\ of\ complete\ tree = 1 \ll result - 1$

---

105. Construct BT from Preorder & In-order Traversal

106. Construct BT from in-order & Post-order Traversal

$map(inorder[i] \rightarrow i)$

$TreeNode\ buildBT(preorder, l, r, inorder, p, q)$

$if(l > r\ ||\ p > q): return\ null$

$index = map[preorder[l]]$

$root = TreeNode(inorder[pos])$

$left \cdot size = index - p, right \cdot size = q - index$

$o.left = build(preorder, l+1, l+left \cdot size, inorder, p, index-1)$

$o.right = build(preorder, l+left \cdot size+1, r, inorder, index+1, q)$

---

108. Convert Sorted Array to BST

$TreeNode\ sortedArray2BST(int[\,]\ A, int\ l, int\ r)$:

$if(l > r)$: $return\ null;$

$m \coloneqq \frac{l+r}{2}$

$TreeNode\ root \leftarrow new\ TreeNode(A[m])$

$root.left \coloneqq sortedArray2BST(A, l, m-1)$

$root.right \coloneqq sortedArray2BST(A, m+1, r)$

$return\ root$

---

109. Convert Sorted List to BST Zenefits

$n \coloneqq 0, p \coloneqq head$

$while(p \neq nil)$: $n \coloneqq n+1, p \coloneqq p.next$

$list2bst(int\ n)$:

$if(n \leq 0\ or\ head = nil)$: $return\ nil$

$l = list2bst\left(\frac{n}{2}\right)$ $\star$ *build the left · subtree, head has been moved by* $\frac{n}{2}$ *steps*

$root = TreeNode(head.val)$

$root.left = l$

$head = head.next$

$root.right = list2bst\left(n-1-\frac{n}{2}\right)$ $\star$ *build the right · subtree*

$return\ root$

---

255. Verify Preorder Sequence in Binary Search Tree

Algorithm #1

$verify \cdot preorder(preorder = [array])$

$if(root = null)$: $return\ true$

$Stack\langle int\rangle\ st = \{\phi\}, low = -2^{31}$

```
    for(int x: preorder):
        if(x < low): return false
        while(st.size > 0 & x > st.peek()): low = st.pop()
        st.push(x)
    return true
```

Algorithm #2

```
index := 0, size := 0
bool verifyPreorder(int[ ] preorder):
    n := len(preorder)
    mi := −2^31, mx := 2^31 − 1
    TreeNode R := build(preorder, mi, mx)
    return size = n

TreeNode build(int[ ] preorder, int mi, int mx):
    if(index = len(preorder)): return nil
    if(preorder[index] ∈ [mi, mx]):
        R := TreeNode(preorder[index])
        index := index + 1
        R.l := build(preorder, mi, R.val)
        R.r := build(preorder, R.val, mx)
        return R
    return null
```

114. Flatten Binary Tree to Linked List

426. Convert Binary Search Tree to Sorted Doubly Linked List Facebook

```
flatten(root):
    if(root is null): return
    flatten(root.left):
    if(prev = nil): head := root
    else: prev.right := root, root.left := prev
    flatten(root.right):
```

116. Populating Next Right Pointers in each Node

117. Populating Next Right Pointers in each Node II **Microsoft**

```
void connect(Node o):
    if(o is null):return
    o.nextR = null
    while(o ≠ null):
        p = o
        while(p ≠ null):
            if(p.left ≠ null):
                if(p.right ≠ null):p.left.nextR = p.right
                else:p.left.nextR = find · nephew(p)
            if(p.right ≠ nil):p.right.nextR = find · nephew(p)
            p = p.nextR
        if(o.left ≠ nil):o = o.left
        elif(o.right ≠ nil):o = o.right
        else:o = find · nephew(o)

Node find · nephew(p:Node):
    q = p.nextR
    while(q ≠ nil):
        if(q.left ≠ nil):return q.left
        if(q.right ≠ nil):return q.right
        q = q.nextR
    return nil
```

Queue & Stack & Greedy& Heap

155. Minimum Stack

Follow Up: Maximum & Minimum Stack **ForUsAll**

solution: maintain three variables: $stack, min$ & max

Algorithm

$push(x)$:

$if\,(stack.size = 0): max = x, stack.push(0)$

$else: stack.push(x - max_{current}), max_{current} = \max(x, max_{current}),$

$top()$:

$if\,(stack.peek \leq 0): \star\star\ x < max_{prev}, max_{current} = max_{prev}$

$return\ x = stack.peek + max_{current}(max)$

$elif\,(stack.peek > 0): \star\star\ x > max_{prev}, max_{current} = x$

$return\ max_{current}(max)$

$pop()$:

$result = top()$

$if\,(stack.peek \leq 0): \star\star\ x < max_{prev}, max_{current} = max_{prev}$

$\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star\star$

$elif\,(stack.peek > 0): \star\star\ x > max_{prev}, max_{current} = x, max_{current} - dif = max_{prev}$

$max = max - stack.peek$

$stack.pop()$

$return\ result$

$get \cdot max()$:

$return\ max$

---

232. Implement Queue using Stacks **Microsoft** **Bloomberg**

solution: apply two stacks, one is called “in”, another is called “out”.

When new element comes in, push it in the “in” stack, in case of the pop operation of queue, there are two cases two be handled, if the “out” stack is not empty, then pop the top one, otherwise, push all the elements in the “in” stack and pop the top one of “out” stack.

346. Moving Average from Data Stream **Uber**

$Deque\ dq \leftarrow \{\phi\}$

$class\ MovingAvg$:

$private\ int\ size, window \cdot sum$

$public\ MovingAvg(int\ size)$:

$size = sz, windowm \cdot sum = 0$

$public\ double\ next(int\ val)$:

$dq.addLast(val);$

$windom \cdot sum += val$

$if(dq.size > size)$:

$dq.pollFirst()$

$window \cdot sum -= val$

$return \frac{window \cdot sum * 1.0}{dq.size}$

---

341. Flatten Nested List Iterator Uber

Solution: DFS / Stack

$dfs(List\langle NestedInteger\rangle\ list, int\ idx)$:

$if(idx == list.size): return;$

$if(list[idx].isNumber): result.add(list[idx])$

$else: dfs(list[idx],0), dfs(list, idx + 1)$

Stack Solution:

$List\ flatten(List\langle NestedInteger\rangle\ list)$:

$List\ result \leftarrow \{\phi\}$

$for(NestedInteger\ each: list): stack.push(each)$

$while(stack\ isn't\ empty)$:

$NestedInteger\ top \leftarrow stack.pop()$

$if(top\ is\ a\ number)$:

$result.addFirst(top)$

$else$:

$for(NestedInteger\ ne: top): stack.push(ne)$

$return\ result$

---

225. Implement Stack using Queues

solution:

```
void push(int x):
    queue.offer(x)
    for(i = 0; i < queue.size − 1; ): queue.offer(queue.poll())
```

321. Create Maximum Number Google

```
int[ ] maxNumber(int[ ] nums1, int[ ] nums2, int k):
    m ≔ len(nums1), n ≔ len(nums1), re = [k]
    for(len = 0 → k):
        if(len < m & k − len < n):
            int[ ] A ≔ maxNumberOfKdigits(nums1, len)
            int[ ] B ≔ maxNumberOfKdigits(nums2, k − len)
            re ≔ max(re, merge(A, B))
    return re

int[ ] maxNumberOfKdigits(A, len):
    re = [len], Stack stack
    for(i = 0 → len(A) − 1):
        remains ≔ len(A) − i − 1 ⋆ [i + 1, len(A) − 1]
        while(A[i] > A[stack.peek] & remains + stack.size ≥ k): stack.pop
        if(stack.size < k) stack.push(i)
    e ≔ len − 1
    while(~stack.empty): re[e--] ≔ A[stack.pop]
    return re

int[ ] merge(A, B):
    i = 0, j = 0, re = [len(A) + len(B)]
    while(i < len(A) & j < len(B)):
        if(compare(A, i, B, j)): re[e++] ≔ A[i++]
        else: re[e + +] = B[j + +]
    while(i < len(A)): re[e + +] = A[i + +]
    while(j < len(B)): re[e + +] = B[j + +]
    return re
```

```
int compare(A, i, B, j):
    while(i < len(A) &j < len(B) & A[i] = B[j]): i := i + 1, j := j + 1
    if(i < len(A) & j < len(B)): return A[i] − B[j]
    elif(i < len(A) & j = len(B)): return 1
    else: return − 1

int max(int[ ] A, int[ ] B):
    for(i = 0 → len(A)):
        if(A[i] > B[j]): return A
        else: return B
    return A
```

---

316. Remove Duplicate Letter Google

Given a string which contains only lowercase letters, remove duplicate letters so that every letter appears once and only once. You must make sure your result is the smallest in lexicographical order among all possible results.

```
remove · duplicates(s):
    distincts := 0
    for(i = 0 → len(s) − 1):
        remains[s[i]] := remains[s[i]] + 1
        if(remain[s[i]] = 1): distincts := distincts + 1
    stack[int] st: ascending order
    used: hashset
    for(i = 0 → len(str) − 1):
        counts[strs[i]] := counts[strs[i]] − 1
        * if current char has not shown up in the stack and the remainings > 0
        while(~st.empty & !used[s[i]] & s[stack.peek] > s[i] & remains[stack.peek] > 0):
            used[stack.pop] := false
        if(stack.size < distincts):
            stack.push(i)
            onstack[s[i]] = true
    re = ""
    while(~st.empty): re := re + s[st.pop]
```

$return\ reverse(s)$

---

402. Remove K Digits Google Snapchat

Given a non-negative integer num represented as a string, remove k digits from the number so that the new number is the smallest possible.

Intuition & Algorithm

The same idea as **316. Remove Duplicate Letter.**

224. Basic Calculator

227. Basic Calculator II Uber

$$\star \textbf{ or } / \ > \ +, -$$

$$) \ > \ ($$

II. only +, -, *, /

$i \leftarrow 0, le \leftarrow exp.length$

$while(i < le \ \& \ exp[i] == \backslash s)\ i \leftarrow i + 1$

$if(i == le): return\ 0$

$first \leftarrow 0$

$while(i < le \ \& \ exp[i] \in [0,9]): first \leftarrow first * 10 + (exp[i++] - '0')$

$if(i == le): return\ first$

$result = first, update = first$

$while(i < le):$

    $while(i < le \ \& \exp[i] == \backslash s): i \leftarrow i + 1$

    $if(i == le): break$

    $nb \leftarrow 0, \ * nb\ is\ short\ for\ number$

    $if(exp[i]\ is\ '+'):$

        $while(i < le \ \& \ exp[i]\ isn't\ a\ digit): i := i + 1$

        $while(i < le \ \& \ exp[i]\ is\ a\ digit): nb \leftarrow nb \star 10 + (exp[i++] - '0')$

        $result \leftarrow result + nb, update := +nb$

    $elif(exp[i]\ is\ '-'):$

        $while(i < le \ \& \ exp[i]\ isn't\ a\ digit): i \leftarrow i + 1$

        $while(i < le \ \& \ exp[i]\ is\ a\ digit): nb \leftarrow nb * 10 + (exp[i++] - '0')$

$result \leftarrow result - nb, update \coloneqq -nb$

$elif(exp[i]\ is\ '*'):$

$while(i < le\ \&\ exp[i]\ isn't\ a\ digit): i \leftarrow i + 1$

$while(i < le\ \&\ exp[i]\ is\ a\ digit): nb \leftarrow nb * 10 + (exp[i++] - '0')$

$result \coloneqq result - update + update * nb, update \coloneqq update * nb$

$elif(exp[i]\ is\ '/'):$

$while(i < le\ \&\ exp[i]\ isn't\ a\ digit): i \leftarrow i + 1$

$while(i < le\ \&\ exp[i]\ is\ a\ digit): nb \leftarrow nb * 10 + (exp[i{+}{+}] - '0')$

$result \coloneqq result - update + \frac{update}{nb}, update \coloneqq \frac{update}{nb}$

$return\ result$

---

150. Evaluate Reverse Polish Notation

20. Valid Parentheses

$for(i = 0; i < s.length;):$

$if(stack.notempty\ \&\ stack.peek == '('\ \&\ s[i] == ')'): stack.pop()$

$else: stack.push(s[i])$

Interview Q: Heap Sort Didi Labs

Build the max-heap first, then each time shrink the array by swapping the last element with the first one, and reconstruct the max-heap again.

$for\left(i = \frac{n}{2} - 1; i \geq 0;\right):$

$*\ build\ the\ maxheap\ from\ bottom\ to\ top$

$heapify(array = A, size = n, index = i)$

$for(i = n - 1; i \geq 0;):$

$swap(A, i, 0)$

$heapify(A, size = i, 0)$

$void\ heapify(A, size, i):$

$lchild \leftarrow 2i + 1, rchild \leftarrow 2i + 2, largest \leftarrow i$

$if(lchild < size\ \&\ A[lchild] > A[largest]): largest \leftarrow lchild$

$if(rchild < size\ \&\ A[rchild] > A[largest]): largest \leftarrow rchild$

$if(largest \neq i):$

$swap(A, largest, i)$

$heapify(A, size, largest)$

---

295. Find Median from Data Stream

Intuition & Algorithm #1

Maintain two heaps, one max-heap, storing the smaller half, and one min-heap, storing the larger half.

Solution I: max-heap, store the smaller half, min-heap, for the larger half.

$void\ add(x)$:

$if(min.empty\ ||\ x \geq min.peek)$:

$min.offer(x)$

$if(min.size - max.size > 1): max.offer(min.poll)$

$elif(max.empty\ ||\ x \leq max.peek)$:

$max.offer(x)$

$if(max.size - min.size > 1): min.offer(max.poll)$

$else$:

$min.offer(x)$

$if(min.size - max.size > 1): max.offer(min.poll)$

$int\ get \cdot median()$:

$if(min.size = max.size)\ return\ \frac{min.peek() + max.peek()}{2.0}$

$else\ if(min.size > max.size)\ return\ min.peek()$

$else: return\ max.peek()$

Intuition & Algorithm #2

Array-list for storing, quick-select for fetching the median.

239. Sliding Window Maximum

$for(i = 0; i < n; ++i)$:

$while(q.size > 0\ \&\ a[i] > a[q.tail]): q.pollLast$

$q.addLast(i)$

$while(q.size > 0 \ \& \ q.tail - q.head + 1 > k): q.pollFirst$

$if(i \geq k - 1): result.add(a[q.head])$

Follow Up: Sliding Window Max Difference

Solution: it just needs an another deque maintaining an ascending order of integers.

$for(i = 0; i < n; ++i):$

$while(qmx.not\ empty \ \& \ a[i] > a[qmx.tail]): qmx.pollLast()$

$while(qmi.not\ empty \ \& \ a[i] < a[qmi.tail]): qmi.pollLast()$

$qmx.addLast(i)$

$qmi.addLast(i)$

$while(qmx.notempty \ \& \ qmx.tail - qmx.head + 1 > k): qmx.pollFirst()$

$while(qmi.notempty \ \& \ qmi.tail - qmi.head + 1 > k): qmi.pollFirst()$

$if(i \geq k - 1): result.add(a[qmx.head] - a[qmi.head])$

---

407. Trapping Rain Water II

$for(boundary\ cell: matrix):$

$heap.offer(cell\{x, y, height\})$

$visited[cell.x][cell.y] = true$

$while(heap.notempty):$

$cell\ c = heap.pop()$

$h = c.height$

$for(i = 0 \rightarrow len(dirs) - 1):$

$n_x, n_y = (c.x, c.y) + dirs[i]$

$if\big(visited[n_x, n_y] = false \ \& \ mat[n_x, n_y] < h\big):$

$visited[n_x, n_y] = true$

$water \coloneqq water + h - mat[n_x, n_y]$

$heap.push\Big(cell\big(n_x, n_y, mat[n_x, n_y]\big)\Big)$

$return\ water$

---

252. Meeting Rooms I Facebook

I: Given a list of $(start, end)$ conference time intervals, check if one can take all intervals.

$sort\ interval\ array\ by\ start\ time$

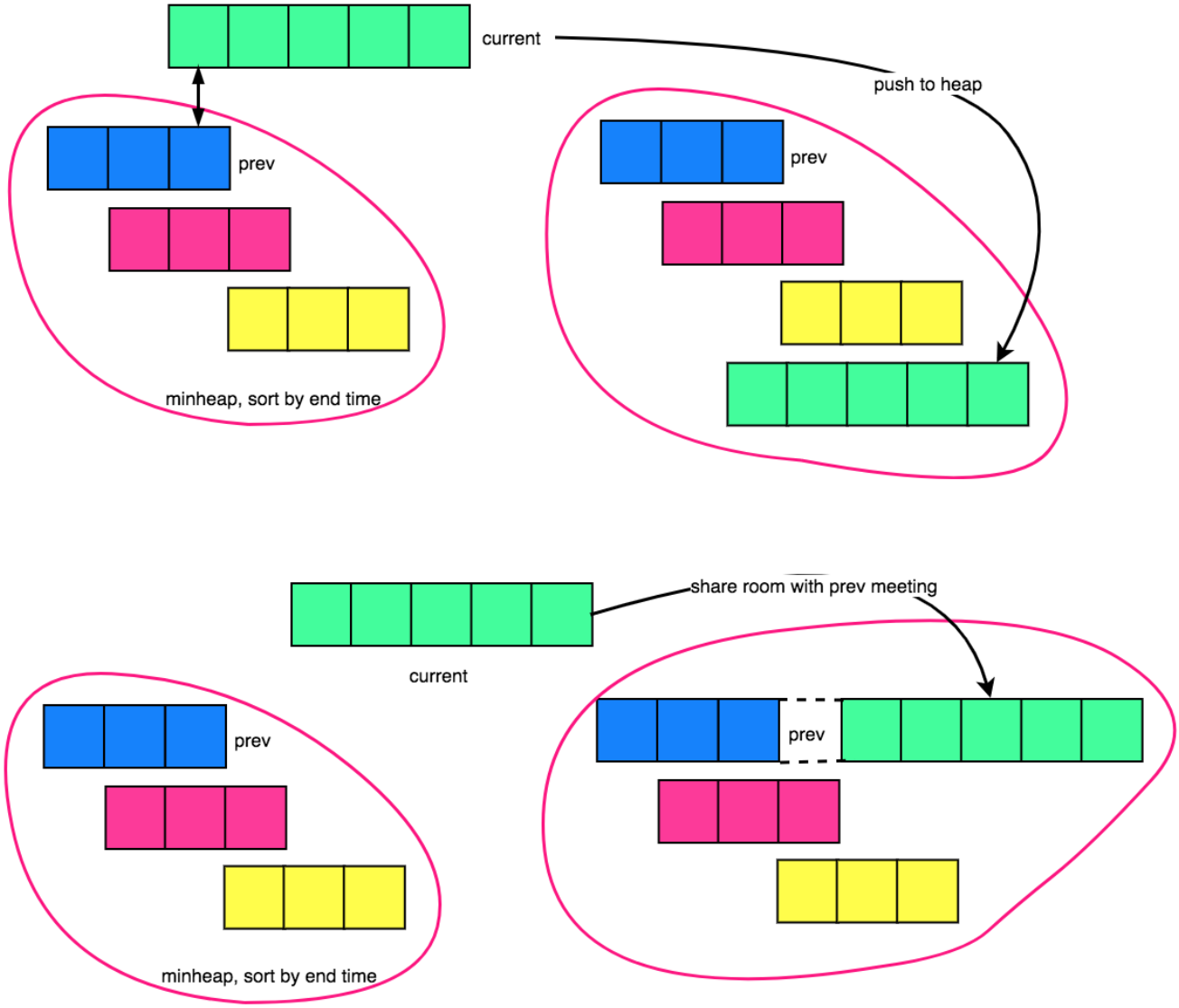
$for(i = 1; i < intervals.length;)$:

$\quad if(interval_{i-1}.end > interval_i.start): return\ false$

$return\ true$

253. Meeting Rooms II Facebook

Find minimum rooms for arranging n meeting intervals.



$sort(intervals)_{a.start-b.start}$ ⋆ *only sort by start, no need consideration for end*

$min \cdot heap\ heap_{a.end-b.end}$ ⋆ *only sort by end, no need consideration for start*

$heap.offer(interval_0)$ ⋆ *arrange the* 1^{st} *meeting*

$for(i = 1 \rightarrow len(intervals) - 1)$:⋆ *arrange meeting which starts earliest.*

```
    interval prev := heap.poll ⋆ check the meeting which ends earliest
    interval curr := intervals[i]
    if (prev.end > curr.start):⋆ collision detected, need one more room
        heap.offer(curr)
        heap.offer(prev).
    else:
        prev.end = max(prev.end, curr.end)
        heap.offer(prev)
return heap.size
```

Find the point where maximum intervals overlap Uber

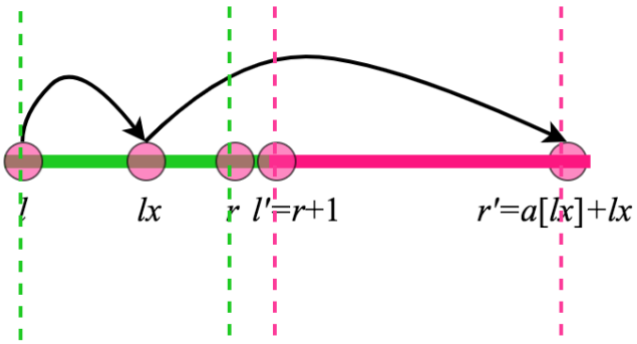
```
Arrays.sort(array = arrive, size = n)
Arrays.sort(array = exit, size = n)
i = 1, j = 0, in = 1
while(i < n & j < n)
    if (arrive[i] ≤ exit[j]):
        in ← in + 1
        if (maxOverlap < in):
            maxOverlap ← in
            map[maxOverlap].add(arrive[i])
        i = i + 1
    else:
        in = in − 1
        j = j + 1
return map[maxOverlap]
```

Intuition & Algorithm #2

```
timeLine[timestamp ⇒ overlapNum]: TreeMap
for(itv: intervals):
    timeLine[itv.start] := timeLine[itv.start] + 1
    timeLine[itv.end] := timeLine[itv.end] − 1
    re = max(timeLine[itv.start], re)
return re
```

55. Jump Game I

45. Jump Game II Microsoft



Intuition & Algorithm

Each time select one point $lx \in [l, r]$, which maximize the value of $a[lx] + lx$. And fnally update the window from $[l, r] \Rightarrow [r + 1, a[lx] + lx]$.

$jumps = 0, l = 0, r = 0, nr \coloneqq 0$

$while(l \leq r)$:

  $if(r \geq n - 1)$: $return\ jumps$

  $for(l \leq r; l \coloneqq l + 1)$:

    $nr \coloneqq \max(next_r, l + nums[l])$

  $r \coloneqq nr$

  $jumps \coloneqq jumps + 1$

---

343. Integer Break

$for\big(factor = 1 \to \lceil\sqrt{n}\rceil\big)$:

  $times \coloneqq \frac{n}{factor}$

  $remain \coloneqq mod(n, factor)$

  $if(remain = 0)$: $re = max\{result, factor^{times}\}$

  $else$: $re = \max\big(re, factor^{times-1} * (remain + i), factor^{times} \star remain\big)$

---

397. Integer Replacement

$function(n)$:

  $if(n\ is\ odd)$:

$if\left(\frac{(n+1)}{2}\&1 == 0\right): return\ function(n+1)+1$

$elif\left(\frac{n-1}{2}\&1 == 0\right): return\ function(n-1)+1$

$if(n\ is\ odd): return\ function\left(\frac{n}{2}\right)$

---

14. Longest Common Prefix Yelp

Apply Trie algorithm

```
class trie · node{int childNumber, randomChild, next[26]}
TrieNode root ← new TrieNode()
insert(TrieNode o, String str):
    p ← o
    for(char c: str):
        idx ← c − 'a'
        if(p.next[idx] is null):
            p.randomChild = idx
            p.next[idx] = new TrieNode()
            p.childNumber+= 1
        p ← p.next[idx]

longest · common · prefix():
    while(true):
        if(p.childNumber ≠ 1): break
        elif(p.childNumber == 1): result+= (char)(p.randomChild + 'a')
```

---

49. Group Anagrams

Solution I: $map[sorted\ word_i] \rightarrow word_i$

Solution II: assign an unique prime number product for string.

187. Repeated DNA Sequence

151. Reverse words in a string

Solution: reverse each word, then reverse the whole string.

6. Zigzag Conversion

214. Shortest Palindrome

Apply KMP algorithm of $s\ and\ s'reverse$

DFS & BFS

360. Valid Sudoku & Sudoku Solver

51. N-Queens & II (52) Zenefits

78. Subsets (Duplicated Subsets allowed)

90. Subsets II (No Duplicated Subsets allowed) Facebook

Given a collection of integers that might contain duplicates, *nums*, return all possible subsets.

The solution set must **not contain duplicate subsets**.

Intuition & Algorithm

$List[List[int]]\ subsets(int[\ ]\ A)$:

$sort(A)$

$List[int]\ load := \{\phi\}$

$List[List[int]]\ re := \{\phi\}$

$int\ idx := -1$

$dfs(A, idx, load, re)$

$return\ re$

$void\ dfs(int[\ ]\ A, int\ idx, List[int]\ load, List[List[int]]\ re)$:

$re.add(new\ ArrayList(load))$

$for(n_x := idx + 1 \rightarrow len(A) - 1)$:

$if\ (n_x > idx + 1\ \&\ A[n_x] = A[n_x - 1])$: $continue \rightarrow$ ***important***!! *to avoid duplicates*

$load.add(A[n_x])$

$dfs(A, nx, load, re)$

$load.remove(load.size - 1)$

---

79. Word Search

Intuition

DFS + Backtrack

22. Generate Parentheses Google Uber Zenefits

$List\langle String\rangle\ result = \{\phi\}$

$dfs(l, r, n, s)$:

$if(l = r\ \&\ l = n): result.add(s)$

$if(l < n): dfs(l + 1, r, n, s+'(')$

$if(l < r): dfs(l, r + 1, n, s+')')$

---

46. Permutation

47. Permutation II

384. Shuffle an Array

$dfs(l, r, a[\,])$:

$if(l > r): result.add(a),\ return;$

$for(k = l \rightarrow r)$:

$swap(a, l, k)$

$dfs(l + 1, r, a)$

$swap(a, l, k)$

---

39. Combination Sum

40. Combination Sum II Uber

Intuition & Algorithm

The key idea of avoiding duplicates is $if(i > idx + 1\ \&\ A[i] = A[i-1]): continue$

$List\langle List\langle int\rangle\rangle\ combination \cdot sum(int[]\ A, int\ target)$:

$List\langle List\langle int\rangle\rangle\ result = new\ ArrayList\langle\rangle\ ()$

$Arrays.sort(A)$

```
    dfs(A, result, candidate = [ϕ], sum = 0, target, idx = −1)
    return result

dfs(A, result, load, sum, target, idx)
    if (sum > target): return;
    if (sum = target): result.add(load), return
    for(i = idx + 1 → len(A) − 1):
        if (i > idx + 1 & A[i] = A[i − 1]): continue
        load.add(A[i])
        dfs(A, result, load, sum + A[i], target, i)
        load.remove(load.size − 1)
```

---

54. Spiral Matrix & II (59) Google Microsoft Uber

```
while(true):
    for(j = left; j ≤ right; ): print(a[top, j]) ⋆ scan the top
    top ≔ top + 1 ⋆ remove the top ⋆, if (left > right || top > bottom): break;

    for(i = top; i ≤ bottom; ): print(a[i, right]) ⋆ scan the right
    right ≔ right − 1 ⋆ remove the right, if (left > right || top > bottom): break;

    for(j = right; j ≥ left; ): print(a[bottom, j]) ⋆ scan the bottom
    bottom ≔ bottom − 1 ⋆ remove the bottom, if (left > right || top > bottom): break;

    for(i = bottom; i ≥ top; ): print(a[i, left]) ⋆ scan the left
    left ≔ left + 1 ⋆ remove the left, if (left > right || top > bottom): break;
```

---

112. Path Sum I

113. Path Sum II

129. Sum Root to Leaf Numbers

```
boolean path · sum(TreeNode o, int sum):
    if (o is null): return false
    if (o is a leaf): return sum = o.val
```

$if\big(path \cdot sum(o.l, sum + o.val)\ ||\ path \cdot sum(o.r, sum + o.val)\big)$:

$return\ true$

$return\ false$

II. Solution: DFS + backtrack

$dfs(TreeNode\ o, List\langle int\rangle candiate, int\ s, int\ sum)$:

$if(o\ is\ a\ leaf)$:

$if(s = sum): result.add(candidate)$

$return$

$if(o.left \neq nil)$:

$candidate.add(o.left.val)$

$dfs(o.left, candidate, s + o.left.val, sum)$

$candidate.remove\ last$

$if(o.right \neq nil)$:

$candidate.add(o.right.val)$

$dfs(o.right, candidate, s + o.right.val, sum)$

$candidate.remove\ last$

---

400. N-th Digit

43. Multiply Strings **Uber** **Facebook** **Twitter**

$reverse(a), reverse(b)$

$re = [len(a) + len(b)]$

$for(i = 0 \rightarrow len(a) - 1)$:

$for(j = 0 \rightarrow len(b) - 1)$:

$re[i + j] \coloneqq re[i + j] + a[i] \star b[j]$

$for(i = 0 \rightarrow len(re) - 1)$:

$re[i + 1] \coloneqq re[i + 1] + \frac{re[i]}{10}$

$re[i] \coloneqq mod(re[i], 10)$

$i \coloneqq len(re) - 1$

$while(i \geq 1\ \&\ re[i] = 0): i \coloneqq i - 1$

$for(; i \geq 0;): result \leftarrow result.append(arr_i)$

---

50. Pow(x, n)

$x^{11} = x^8 \star x^2 \star x^1$

$pow(x, n)$:

$if(n = 0): return\ 1$

$temp \leftarrow x$

$while(n > 0)$:

$if(n\ \&\ 2 = 1): re \star= temp$

$n = \frac{n}{2}$

$temp\ *= x\ (temp = x^1, x^2, x^4, x^8)$

372. Super Pow

$a^{1234} = (a^{1000})^1(a^{100})^2(a^{10})^3(a^1)^4$

$super \cdot pow(a, b[])$

$result = 1, a = mod(a, 1337)$

$for(i = b.length - 1; i \geq 0;)$:

$result = result * mod(fastRow(a, b[i]), 1337)$

$a = fastRow(a, 10)$

149. Max Points on a Line

$result = 0$

$for(i = 0; i < p.length;)$:

$same = 0, vertical = 0, e = 1$

$for(j = 0; j < p.length;)$

$if(i = j): continue$

$if\big(p_i.x = p_j.x\ \&\ p_i.y = p_j.y\big): same+= 1$

$elif\big(p_i.x = p_j.x\big)\ vertical+= 1$

$else: map\left[\frac{[(p_i.y - p_j.y)}{p_i.x - p_j.x}\right] += 1$

$e = \max(same + \max(map\left[\frac{[(p_i.y - p_j.y)}{p_i.x - p_j.x}\right]), vertical)$

$result = max\{result, e\}$

342. Power of Four Uber

$is \cdot power \cdot 4(int\ num)$:

    $double\ x = \log_4(num)$

    $double\ y = Math.floor(x)$

    $if(|x - y| < 10^{-6}): return\ true$

    $return\ false$

$double \log_4(int\ num)$:

    $return\ (\log_{10}(num))/\log_{10}(4)$

Solution II:

$4^n - 1 = (4-1)(4^{n-1} + 4^{n-2} + \cdots + 4^1 + 1) = 3K$

$return\ num\ \&\ (num-1) == 0\ and\ num > 0\ and\ (num-1)\%3 == 0$

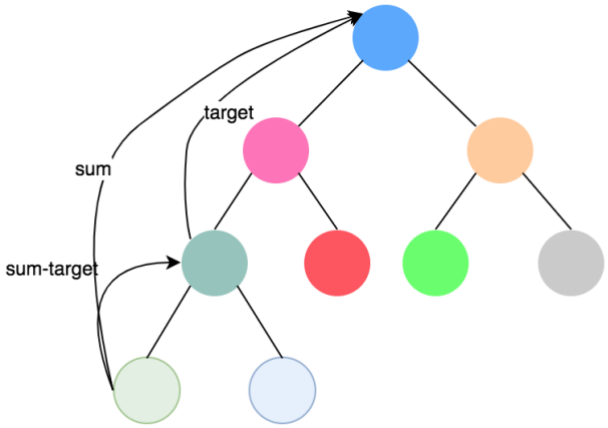
326. Power of Three

$re = n > 0\ \&\ n\ \&\ (n-1) = 0\ \&\ mod(n-1, 3) = 0$

Hash Map & Tree Map & BIT

437. Path Sum III

You are given a binary tree in which each node contains an integer value. Find the number of paths that sum to a given value. The path does not need to start or end at the root or a leaf, but it must go downwards (traveling only from parent nodes to child nodes).



Intuition & Algorithm

The same idea as "count how many subarrays that sum to target", use $sum_{current}$ to keep track of the sum from root node to current node, and $map[sum_{current}, times]$ to record the number of times that the sum of root nodes down to current node shows up.

$map[0] = 1$

$re = dfs(o, map, sum_{current} = 0, target)$

$dfs(TreeNode\ o, Map\langle int, int\rangle\ map, int\ sum_{current}, int\ target)$:

    $if(o\ is\ null): return\ 0$

    $sum_{current} := sum_{current} + o.val$

    $re := re + map[sum_{current} - target]$

    $map[sum_{current}] := map[sum_{current}] + 1$

    $re := re + dfs(o.left, map, sum_{current}) + dfs(o.right, map, sum_{current})$

    $map[sum_{current}] := map[sum_{current}] - 1$

    $return\ result$

Number of subarrays having sum exactly equal to k GeeksForGeeks

---

$int\ findSubarraySum(int[\,]\ \mathcal{A}, int\ \mathcal{T})$:

    $map: Presum \Rightarrow counts$

    $re := 0$

    $s := 0$

    $map[0] := 1$

    $for(i = 0 \to len(\mathcal{A}) - 1)$:

        $s := s + \mathcal{A}[i]$

        $re := re + map[s - \mathcal{T}]$

        $map[s] := map[s] + 1$

    $return\ re$

---

1. Two Sum

$O(n)\ solution: hash \cdot map$

$O(\log(n) * n)\ solution: sort + 2\ pointers$

Interview Q. Uber

Implement a hash-map which supports 3 operations: put, get & putAll(value), to be noticed, putAll(value) updates all KV pairs with the new value.

```
public class MyMap<K,V>:
    private Map<K, V> map
    private Set<K> nonAffectedkeys
    private V val = null
    public void put(K key, V value):
        keys.add(key)
        map[key] = value
    public T get(K key):
        if(nonAffectedkeys.contains(key)): return map[key]
        else return val
    public void putAll(V value):
        keys.clear() | keys = new HashSet
        val = value
```

Interview Q. Uber

Given a hash-map, like "apple":10, "banana":50, "peach":30

The value part suggests the relative weight, this question ask you to randomly output a key in accordance with the corresponding weight.

```
rid = rand.nextInt(range = ∑map.values)
pos ← 0, id ← 0
it ← map.entrySet().iterator(), result = ""
while(pos < rid & it.hasNext()):
    KV ← it.next(), result = KV.getKey(), weight ← KV.getValue()
    pos ← pos + weight
return result
```

The above algorithm takes $O(n)$ time

Solution II:

If the input is given in a array format (or we can export the KV pairs in hash-map into an array), we can search the target using binary search $O(\log n)$

```
arr = ["apple": 10, "banana": 50, "peach": 30]
```

$sum = [10,60,90]$

$l = 0, r = arr.length - 1$

$while(l < r)$:

    $mid = (l + r) \gg 1$

    $if(sum_{mid} - sum_l + arr[l].weight < rid): l = mid + 1$

    $elif(sum_{mid} - sum_l + arr[l].weight == rid): return\ arr[mid].key$

    $else: r = mid$

$return\ arr[l].key$

---

525. Contiguous Array Facebook

Given a 01 array, find the maximum length of a contiguous subarray with equal number of 0 and 1.

Intuition & Algorithm

Translate the $A[i] = 0 \to -1$, then this problem is to find such a longest subarray whose sum equals to zero.

$map \coloneqq \{prefixsum \Rightarrow index\}$

$map[0] \coloneqq -1$

$s \coloneqq 0, re \coloneqq 0$

$for(i = 0 \to n - 1)$:

    $s \coloneqq s + (A[i] < 0) \to -1 : 1$

    $if(s = 0): re \coloneqq \max(re, i)$

    $if(map[s] \neq nil): re \coloneqq \max(re, i - map[s])$

    $if(map[s] = nil)\ map[s] = i$

$return\ re$

---

325. Maximum Size Subarray Sum Equals k Facebook Palantir

$mp: (type = (int \to int), default: mp[0] = -1)$

$for(i = 0 \to n - 1)$:

    $sum = sum + arr[i]$

    $if(mp[sum - k] \neq null): result = \max(result, i - mp[sum - k] + 1)$

    $if(mp[sum] == null)$:

$*\ if\ sum\ occurs\ more\ than\ once, only\ record\ the\ leftmost\ index\ asscociated\ with\ it$

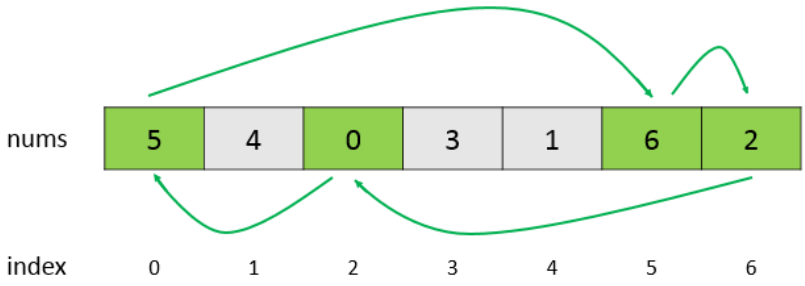
$mp[sum] = i$

Follow Up: if it is asked to find the minimum size subarray, then just remove the blue line of code above.

565. Array Nesting Apple

A zero-indexed array A of length N contains all integers from 0 to $N-1$. Find and return the longest length of set S, where $S[i] := \left(A[i], A\left[A[i]\right], A\left[A\left[A[i]\right]\right], \dots\right)$ subjected to the rule below.

i.e. $A = [5,4,0,3,1,6,2]$, $re = (A_0 = \mathbf{5} \to A_5 = 6 \to A_6 = 2 \to A_2 = 0 \to A_0 = \mathbf{5})$ form a cycle with length of 4.



Elements 5, 0, 6, 2 are added to the current set, if we start with any of the index from 0, 2, 5, 6

Intuition & Algorithm

$int\ arrayNesting(int[\ ]\ A)$:

$bool[\ ]\ used := [len(A)]$

$re := 0$

$for(i = 0 \to len(A) - 1)$:

$if(used[i] = \mathcal{F}alse)$:

$start := A[i], len := 1$

$\star\ \mathcal{M}ark\ all\ number\ is\ a\ cirlce\ as\ visited$

$do: start \coloneqq A[start], len \coloneqq len + 1, used[i] \coloneqq True$

$while(start \neq A[i])$

$re \coloneqq \max(re, len)$

$return\ re$

---

17. Letter Combinations of a Phone Number Uber

Follow Up: Given a phone number list & word dictionary, find the phone number which maps the most number of words.

$map: 2: \{a, b, c\}, 3: \{d, e, f\}, 4: \{g, h, i\}, 5: \{j, k, l\}, 6: \{m, n, o\}, 7: \{p, q, r, s\}, 8: \{t, u, v\}, 9: \{w, x, y, z\}$

$for(word\ w: wordlist)$:

  $for(char\ ch: w): phone \cdot number \leftarrow phone \cdot number.append(map[ch])$

  $word2num[w] \leftarrow phone \cdot number$

$for(string\ word: word2num.keySet())$:

  $phone \cdot number \leftarrow word2num[word]$

  $num2wordlist[phone \cdot number].add(word)$

  $if(num2wordlist.size > maxlen)$:

    $maxlen = num2wordlist.size$

    $result = phone \cdot number$

  $return\ result$

---

200. Number of Islands Google Facebook Microsoft Amazon Zenefits

Given a 2d grid map of '1's (land) and '0's (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.

Algorithm

Nothing trivial, just do DFS by starting from each island (1)

$int\ number \cdot island(grid_{2d})$:

  $for(cell\ c: grid_{2d})$:

    $if(c =' 1')$:

      $visited.add(c)$

      $dfs(c, visited)$

      $island += 1$

---

305. Number of Islands II Google

Intuition & Algorithm

Union-Find, for each of newly added island, we increase the number of islands by 1. Then, find 4-directionally adjacent island and union them, if the union two islands have already in the same group, do nothing. Otherwise, decreasing the number of islands by 1.

```
List[int] numIslands(int m, int n, int[ ][ ] positions)
    re = [ϕ], islands = 0, marked = {ϕ}
    uf = UnionFind(m * n)
    for(i = 0 → len(positions) − 1):
        islands := islands + 1
        x, y = positions[0], positions[1]
        id = x * n + y
        marked.add(id)
        for(k = 0 → len(dirs) − 1):
            n_x, n_y = x + dirs[i, 0], y + dirs[i, 1]
            if(n_x ∈ [0, m − 1] & n_y ∈ [0, n − 1] & marked[n_x * n + n_y] = true):
                nextId = n_x * n + n_y
                bool b = uf.union(id, nextId)
                if(b): islands := islands − 1
        re.add(islands)
```

128. Longest Consecutive Sequence

Solution I: hash-map

```
for(int x: nums): set.add(x)
for(int x: nums):
    if(set[x] ≠ null): continue
    l = x − 1
    while(set[l] ≠ null): set[l] = null, l := l − 1
    r = x + 1
    while(set[r] ≠ null): set[r] = null, r := r + 1
```

$set[x] = null$

$result = \max(result, r - l)$

$find(i)$:

$if(fa[i] \neq i): fa[i] = find(fa[i])$

$return\ fa[i]$

$connect(i, j)$:

$if((o_i = find(i)) \neq (o_j = find(j))):$

$if(rank[o_i] > rand[o_j]): fa[o_j] = o_i$

$elif(rank[o_i] < rank[o_j]): fa[o_i] = o_j$

$else: fa[o_i] = o_j, rank[o_i] += 1$

---

644. Maximum Average Subarray II Google

Find a subarray with a length (≥ k) whose average is the largest.

Solution: binary guess or Simulated Annealing algorithm. Since certainly, such an average satisfying the condition must be in the range of [min, max], so we can continuously enumerate avg in [min, max], and then check if there is a subarray.

$$\sum_{i}^{j} A[x]\ (j - i + 1 \geq k)$$

$$s.t.\ \frac{\sum_i^j A[x]}{(j-i+1)} \geq avg\ or\ \sum(arr[k] - avg)\ \geq 0.$$

$boolean\ check(double\ avg_{est}, nums, k)$:

$sum = 0.0$

$for(i = 0 \to k - 1): sum = sum + nums[i] - avg_{est}$

$if(sum \geq 0.0): return\ true$

$pre_{sum} = 0.0, mi_{presum} = 0.0$

$for(i = k \to n - 1):$

$sum = sum + (nums[i] - avg_{est})$

$pre_{sum} = pre_{sum} + (nums[i - k] - avg_{est})$

$min_{presum} = \min(min_{presum}, pre_{sum})$

$if(sum - mi_{presum} \geq 0): return\ true$

$return\ false$

$findMaxAverage(nums, k)$:

$mi \coloneqq \min(nums[i]), mx \coloneqq \max(nums[i]), \forall i \in [0, len(nums) - 1]$

$if(mi = mx): return\ mx$

$error = 2^{31} - 1, prev_{est} = 0.0$

$while(error > 10^{-6})$:

$avg_{est} = \frac{mi+mx}{2}$

$if\big(check(avg_{est}, nums, k)\big): mi = avg_{est}$

$else: mx = avg_{est}$

$error = |avg_{est} - prev_{est}|$

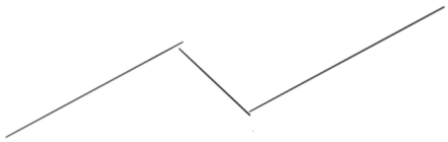
$prev_{est} = avg_{est}$

$return\ mx$

---

665. Non-decreasing Array Google

Check if an array can be non-decreasing by modifying at-most 1 element.



the above picture suggests an example of such array that making an array non-decreasing by modifying at-most one element.

So we just need to find such an position i such that nums[i] > nums[i + 1], and then I make nums[i], nums[i+1] equal by either $nums[i] = nums[i + 1]$r (case i) or $nums[i + 1] = nums[i]$ (case ii)**.** if in either of cases, nums[0: i] is in non-decreasing order and nums[i + 1: n − 1] is also in non-decreasing order. Then return true, return false otherwise.

670. Maximum Swap Facebook

Intuition & Algorithm

At each digit of the input number in order, if there is a larger digit that occurs later, we know that the best swap must occur with the digit we are currently considering. We will compute $last[d] = i$, the index i of the last occurrence of digit d (if it exists).

Afterwards, when scanning the number from left to right, if there is a larger digit in the future, we will swap it with the largest such digit; if there are multiple such digits, we will swap it with the one that occurs the latest.

$int\ maxSwap(int\ x)$:

    $char[\ ]\ A = String(x).toCharArray$

    $int[\ ]\ index = [10]$

    $for(i = 0 \rightarrow len(A) - 1): index[A[i] - 0] = i$

    $for(i = 0 \rightarrow len(A) - 1)$:

        $for(d = 9 \rightarrow A[i] - '0' + 1)$:

            $if(index[d] > i)$:

                $swap(A, i, index[d])$

                $return\ int(A)$

    $return\ num$

Heap-Sort Didi Labs

$heapify(arr, n, i)$:

    $largest \leftarrow i$

    $l \leftarrow largest * 2$

    $r \leftarrow largest * 2 + 1$

    $if\left(l < n\ \&\ arr_l > arr_{largest}\right): largest \leftarrow l$

    $if\left(r < n\ \&\ arr_r > arr_{largest}\right): largest \leftarrow r$

    $if(largest \neq i)$

        $swap(arr, i, largest)$

        $heapify(arr, n, largest)$

$heap \cdot sort(arr)$

    $build \cdot max \cdot heap \begin{cases} for\left(i = \frac{n}{2} - 1; i \geq 0;\right): \\ \quad heapify(arr, n, i) \end{cases}$

    $for(i = n - 1; i \geq 0;)$

        $swap(arr, 0, i) \rightarrow remove\ the\ top$

        $heapify(arr, i, 0) \rightarrow maintain\ max \cdot heap\ for\ arr_0^{n-2}, arr_0^{n-3}, \cdots, arr_0^0)$

K-dimensional Tree

common questions:

range query (find all points inside the given range $R: [x_1, x_2] \times [y_1, y_2]$)

269. Alien Dictionary

examples: input: words[] = {"baa", "abcd", "abca", "cab", "cad"}

output: Order of characters is 'b', 'd', 'a', 'c'

$graph\ g \rightarrow \{\phi\}$

$for(word_i, word_j\ in\ words)$:

$idx \leq \{word_i[id] \neq word_j[id], 0 \leq id < \min\left(len(word_i, word_j)\right)\}$

$add\ directed\ edge\ \{word_i[idx], word_j[idx]\}\ into\ g$

$do\ toppogical\ sort\ on\ g$

---

271. Closest Binary Search Tree Value & 272

$result = 2^{31} - 1, dif = 2^{31} - 1$

$while(root \neq null)$:

$if(|root.val - target| < dif)$:

$dif = |root.val - target|$

$result = root.val$

$if(target < root.val): root = root.left$

$elif(target > root.val): root = root.right$

$else: return\ root.val$

$return\ result$

---

272. Find k Closet Values

$List\langle int\rangle\ closetKvalues(TreeNode\ root, target)$:

$List\langle int\rangle result = \{\phi\}$

$findLeft(root.left, target, lc(type = stack))$

$findRight(root.right, target, rc(type = stack))$

```
    while(result.size() < k):
        if(lc.isEmpty()): result.add(rc.pop())
        elif(rc.isEmpty()): result.add(lc.pop())
        elif(|lc.peek() − target| < |rc.peek() − target|): result.add(lc.pop())
        else: result.add(rc.pop())
    return result

findLeft(TreeNode root, target):
    if(root == null): return
    findLeft(root.right, target, lc)
    lc.push(root.val)
    if(target < root.val): return
    findLeft(root.left, target, lc)
```

Solution 2. flatten BST into sorted list, then find k closet node on list

---

```
static TreeNode head = null
static TreeNode prev = null
flatten(TreeNode root):
    if(root == null): return
    flatten(root.left)
    if(head == null):
        head = root
        prev = root
    else:
        prev.right = root
        root.left = prev
        prev = root
    flatten(root.right)

List⟨int⟩ findkcloset(int target, int k):
    result = {ϕ}
    TreeNode p = findNodeCloset2Target(head, target)
    if(p.left == null): result.add(p → p.right + k − 1)
    elif(p.right == null): result.add(p → p.left − l + 1)
```

```
    else:
        l = p.left, r = p.right, result.add(p.val)
        while(result.size() < k):
            if(|l.val − target| ≤ |r.val − target|):
                result.add(l.val), l = l.left
            else: result.add(r.val), r = r.right
    return result
```

Graph & Topo-sort & Union-Find

127. Word Ladder & II (126) Uber Zillow

```
Queue Q ← {Node(begin_word, 1)}
word_dict.add(end_word)
while(Q.size > 0):
        Node top ← Q.poll
        word ← top.word, level ← top.level
        if(word = end_word) return true
        for(i = 0 → len(word) − 1):
            for(c = a → z):
                if(word[i] ≠ c):
                    temp = word[i], word[i] = c, str_new = String(word[i])
                    if(word_dict[str_new] ≠ null):
                        Q.offer(Node(str_new, level + 1))
                        word_dict.remove(str_new)
                    word_i = temp #backtrack
return false
```

Interview Q. Bipartite graph check Uber

```
queue.offer(node{src, color = 0})
while(queue.is not empty):
    node nd = queue.pop
    u = nd.vertex, color = nd.color
```

```
    if(matrix[u][u] == 1): return false
    for(v: u.adjacent nodes):
        if(color[v] == 1 − color): continue
        elif(matrix[u][v] == none): queue.offer(node{v, 1 − color})
        elif(matrix[u][v] == red): return false
return true
```

---

433. Minimum Genetic Mutation Twitter

Determine the minimum number of mutations needed to mutate from "start" to "end". If there is no such a mutation, return -1.

```
int minMutation(String start, String end, String[ ] bank):
    if(len(bank) = 0): return − 1
    Queue[String] que = {ϕ}, Set[String] genebank = {bank}, Set[String] used = {ϕ}
    level = 0

    while(que.size > 0):
        size = que.size
        used.addAll(que) ⋆ Mark all string on current level as visited
        for(i = 0 → size − 1):
            String gene = que.poll
            if(gene = end): return level
            char[ ] chars = gene.toCharArrayv
            for(j = 0 → len(chars) − 1):
                for(k = 0 → len([A, C, G, T]) − 1):
                    if(chars[j] ≠ elements[k]):
                        swap(chars[j], elements[k])
                        String genex = String(chars)
                        if(geneBank[genex] ≠ nil & used[genex] ≠ nil):
                            que.offer(genex), used.add(genex)
                        swap(chars[j], elements[k])
        level ≔ level + 1
    return − 1
```

---

207. Course Schedule

210. Course Schedule II Facebook Zenefits

There 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.

Intuition & Algorithm

Topological sort

$in[v_i] = 0, v_i \in g.vertex$

$for(edge\ e: g.edges): in[e.to] += 1$

$Queue\ Q = \{\phi\}$

$for(vertex\ v_i \in g.vertex)$

    $if(in[v_i] = 0): Q.add(v_i)$

$while(Q\ is\ not\ empty)$:

    $v = Q.poll()$

    $result.add(v)$

    $for(v_j \in v.adjacent)$:

        $in[v_j] := in[v_j] - 1$

        $if(in[v_j] = 0): Q.offer(v_j)$

$if(result.size \neq g.vertex.number)$: "$no\ solution$"

---

310. Minimum Height Trees **Google**

For an undirected graph with tree characteristics, we can choose any node as the root. The result graph is then a rooted tree. Among all possible rooted trees, those with minimum height are called minimum height trees (MHTs). Given such a graph, write a function to find all the MHTs and return a list of their root labels.

Intuition & Algorithm

Topological Sorting on an undirected graph, we keep removing the node whose indegree is 1, that is, the leaf node. We update minHeightTrees in each level, the last one remained will be the list containing roots.

```
List[int] findMinHeightTrees(int n, int[ ][ ] edges):
    if(len(edges) = 0): return [0]
    g: Map[int, Set[int]], ind = [n], List[int] re = [ϕ]
    for(int[ ] e: edges):
        ind[e[0]] := ind[e[0]] + 1, ind[e[1]] := ind[e[1]] + 1
        g[e[0]].add(e[1]), g[e[1]].add(e[0])

    Queue[int] que = [∀i, ind[i] = 1]
    while(que.size > 0):
        sz = que.size
        re.clear, re.addAll(que)
        for(i = 0 → sz − 1):
            node = que.poll
            for(anode: g[node]):
                ind[anode] := ind[anode] − 1
                if(ind[anode] = 1):
                    que.offer(anode)
    return re
```

Math & Geometry & Number Theory

365. Water and Jug Problem (Number Theory)

You are given two jugs with capacities x and y liters. There is an infinite amount of water supply available. You need to determine whether it is possible to measure exactly z liters using these two jugs. For example, $x = 3, y = 5, z = 4 \rightarrow can\ measure; x = 2, y = 6, z = 5 \rightarrow can't\ measure$ Solution: this is a kind of Euclidean problem, where I can assume you did m times operation on jug_x, n times operations on jug_y to measure $z\ liters: m * x + n * y = \gcd(x, y)$, so z can be measured if & only if $\boldsymbol{mod(z, \gcd(x, y)) = 0}$.

```
canMeasure(x, y, z):
```

$if(z = 0): return\ true$

$if(x + y < z): return\ false$

$if(x > y): swap(x, y)$

$if(z\ mod\ \gcd(x, y) = 0): return\ true$

$return\ false$

$\gcd(x, y)$:

$if(y = 0): return\ x$

$else: return \gcd(y, x\ \%\ y)$

---

367. Valid Perfect Square LinkedIn

Given a positive integer, determine if the given number is perfect square or not.

Intuition & Algorithm

$bool\ isPerfectNum(int\ x)$:

$if(num \leq 0): return\ false$

$low \coloneqq 1, high \coloneqq x$

$while(low < high)$:

$mid \coloneqq \frac{low+high}{2}$

$if\left(\frac{x}{mid} > mid\right): low \coloneqq mid + 1$

$else: high \coloneqq mid$

$return\ low^2 = x$

---

168. Excel Sheet Column Title Facebook Microsoft Zenefits

Given a positive integer, return its corresponding column title as appear in an Excel sheet.

For example,$1 \rightarrow A, 2 \rightarrow B, \cdots, 26 \rightarrow Z, 27 \rightarrow AA, 28 \rightarrow AB$

$string\ convertToTitle(int\ n)$:

$re \coloneqq$ ""

$while(n > 0)$:

$r \coloneqq mod(n, 26)$

$if(r = 0): re \coloneqq$ "Z" $+ re$

$else: re \coloneqq (char)('A' + r - 1) + re$

$n \coloneqq \frac{n}{26}$

$if(r = 0): n \coloneqq n - 1$

---

469. Convex Polygon Google

$boolean\ positve = false, negative = false$

$n = poly.size$

$for(int\ B = 0; B < n; B += 1):$

$A = (B - 1 + n)\ \%\ n, C = (B + 1 + n)\ \%\ n$

$BA = (poly[A].x - poly[B].x, poly[A].y - poly[B].y)$

$BC = (poly[C].x - poly[B].x, poly[C].y - poly[B].y)$

$if(BA\ \times\ BC < 0): negative = true$

$else: positive = true$

$if(postive\ \&\ negative): return\ false$

$return\ true$

Area of Polygon

$for(int\ B = 1; B < poly.size; B += 1):$

$A = (B - 1), C = B + 1$

$BA = (poly[A].x - poly[B].x, poly[A].y - poly[B].y)$

$BC = (poly[C].x - poly[B].x, poly[C].y - poly[B].y)$

$area\ += \frac{BA \times BC}{2}$

Intersection point of ray & triangle-3d.

Triangle-3d can be presented as: $Ax + By + Cz + D = 0$ (1)

Ray can be presented as: $P = O + t \cdot R$ (2).

Supposing the intersection point lies on the triangle is (P_x, P_y, P_z), so we have:

$$AP_x + BP_y + CP_z + D = 0$$

$$A(O_x + tR_x) + B(O_y + tR_y) + C(O_z + tR_z) + D = 0$$

$$(AO_x + BO_y + CO_z) + D = -t(AR_x + BR_y + CR_z)$$

---

because the normal vector of plane (based on triangle) is $N(A, B, C)$, and $(AO_x + BO_y + CO_z) = N \cdot O$, and $(AR_x + BR_y + CR_z) = N \cdot R$, $t = \frac{N \cdot O + D}{N \cdot R}$, so the intersection point is $P = O + \frac{N \cdot O + D}{N \cdot R} R$

Fibonacci progression

Solution: $O(log\ N)\ time$

$$\begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^n = \begin{pmatrix}F_{n+1} & F_n\\ F_n & F_{n-1}\end{pmatrix}$$

$$\begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^n = \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^{\frac{n}{2}} \cdot \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^{\frac{n}{2}} \cdot \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}^{(n\&1)}$$

$$F = \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}\ M = \begin{pmatrix}1 & 1\\ 1 & 0\end{pmatrix}$$

$power(int\ F[][], int\ n)$:

    $if(n \le 1)\ return;$

    $power(F,\ n/2\ )$:

    $multiply(F, F)$

    $if(n\&1 == 1)\ multiply(F, M)$

Check if one number n is a Fibonacci number

$return\ \sqrt{5n^2+4}\ \in Z^+\ ||\ \sqrt{5n^2-4} \in Z^+$

 # Find Path In a Maze

solution: A* algorithm.

$class\ cell\{int\ r, c, g(dist_{source,current}), h(dist_{current,goal}), f(= g + h)\}$

$maintain\ 2\ sets: open(f, cell), closed(cell)$

$intialize\ set\ open\ with\ open = \{0, source\}, closed = \{\}.$

$while(open\ is\ not\ empty)$:

    $cell \leftarrow open.pollfirst(pop\ the\ cell\ with\ the\ smallest\ f)$

    $add\ cell\ into\ closed$

    $for(neighbor\ of\ cell)$:

        $if(neighbor \notin \{closed \cup block\})$:

            $if(neighbor == goal): found = true, return;$

            $g_{new} = cell.g + 1, h_{new} = dis(neighbor, goal), f_{new} = g_{new} + h_{new}$

            $if(neighbor.f > f_{new}): open.update(neighbor, f_{new})^1$

$if(!found)$: "$not\ found$"

$note^1: if\ neighbor\ already\ exists\ in\ the\ open, update\ it\ with\ smallest\ f_{new};$

: otherwise, insert such pair into open

String & Easy

166. Fraction to Recurring Decimal

```
fractionToDecimal(int n, int d) :
    StringBuilder sb = new StringBuilder();
    if((n > 0 & d < 0) || (n < 0 & d > 0)): sb.append("-")
    long num = (long)|n|, den = (long) |d|
    sb.append(Long.toString(num/den)) the integer part
    num %= den
    if(num > 0) sb.append(.)
    map<long, int> ls → map remainder to decimal index
    p = 0, ls[num] = sb.length() (i.e. 20/3 = 6.⋯, remainder = 2), ls[2] = len('6.') = 2
    while(num > 0):
        num := num * 10, sb.append(num/den), num := mod(num, len)
        if(ls[num] ≠ null)
            idx := ls[num])
            sb.insert(idx, '(')
            sb.append(')')
            break
        else: ls[num] = len(sb)
    return sb.toString()
```

29. Divide two Integers

526. Beautiful Arrangement

```
dfs(N, index, used, count)
    if(index > N):
```

$count = count + 1, return$

$for(i = 1 \to N)$:

$used[i] = true$

$dfs(N, index + 1, used, count)$

$used[i] = false$

---

482. License Key Formatting

just familiar with several functions:

$String: replace$(some str,another str), $i.e. replace$("-","")

$String: toUpperCase()$

12. Integer to Roman & Roman to Integer (13) Oscar Health

$unit$: $['', I, II, III, IV, V, VI, VII, VIII, IX]$

$tens$: $['', X, XX, XXX, XL, L, LX, LXX, LXXX, XC]$

$hundreds$: $['', C, CC, CCC, CD, D, DC, DCC, DCCC, CM]$

$thousands$: $['', M, MM, MMM]$

$$result = thousands\left[\frac{x}{1000}\right] + hundreds[\left(\frac{x}{100} mod\ 10\right)] + + tens\left[mod\left(\frac{x}{10}, 10\right)\right] + unit[mod(x, 10)]$$

65. Valid Number

For example, $-12.35789e^{+456}$

$regex = [-+]?(\d+\.? \mid \.\d+)\d*(e[-+]?\d+)?$

Interview Q. Given a word dictionary & a sentence

For example, $dict =$ [this, hi, his, is, word], $sentence =$ thisisaword

$Output =$ [this, hi, his, is, is, word]

Solution: grab all substring of sentence at first, and check each substring exists in dictionary or not.

Optimization: avoid checking too-long substring.

648. Replace Words Uber

Replace words in a string with shortest prefix in dict.

```
String replaceWords(List<String> dict, String sentence):
    String[] words ← sentence.split(" ")
    buildTrie(dict)
    result ← ""
    for(i = 0 → words.length):
        TrieNode p ← root
        j ← 0
        for(; j < words[i].length(); ):
            if(p.next[words[i][j]−'a'] ≠ null):
                p ← p.next[words[i][j]−'a']
                if(p.isWord): break
            else: break
        if(p.isWord): result ← result +  words[i].substring(0, j + 1)
        else: result ← result + words[i]
        if(i < words.length − 1): result ← result + " "
```

412. Fizz Buzz

415. Add Strings

```
char[]a ← new StringBuffer(num1).reverse().toString().toCharArray()
char[]b ← new StringBuffer(num2).reverse().toString().toCharArray()
len ← a.length > b.length? a.length: b.length
result ← array1d(size = len + 1)
for(i = 0 → len):
    ai ← i < a.length? ai: 0
    bi ← i < b.length? bi: 0
    resulti ← ai + bi
```

$for(i = 0 \to len - 2)$:

$result_{i+1} \leftarrow result_{i+1} + result_i/10$

$result_i = result_i \ mod \ 10$

$i \leftarrow len - 1, output = ""$

$while(i \geq 1 \ \& result_i == 0) i \leftarrow i - 1$

$for(; i \geq 0;): output \leftarrow output + result_i$

$return \ output$

---

695. Max Area of Island

Solution: simple dfs

Note: cut branches of dfs tree by turn the "island" to water during dfs.

https://leetcode.com/submissions/detail/140076776/

67. Add Binary Facebook

$char[] \ ca \leftarrow a.reverse().toCharArray()$

$char[] \ cb \leftarrow b.reverse().toCharArray()$

$i = 0, j = 0$

$len = \max(ca.length, cb.length), int[\,] \ re = [len]$

$for(i = 0; i < len;)$:

$int \ a_i = i < ca.length ? ca[i] - '0' : 0;$

$int \ b_i = i < cb.length ? cb[i] - '0' : 0;$

$re_i = a_i + b_i$

$for(i = 0 \to len - 2)$:

$re[i + 1] \coloneqq re[i + 1] + \frac{re[i]}{10}$

$re[i] \coloneqq mod(re[i], 10)$

$i = len - 1$

$for(; i \geq 1 \ \& re[i] = 0; i \coloneqq i - 1);$ ⇒ *remove unnecessary leading zeros*

$result = ""$

$for(; i \geq 0; - - i): result.append(re[i] + '0')$

$return \ result$

---

38. Count and Say Facebook

$StringBuilder\ rs \leftarrow new\ StringBuilder("1")$

$i = 1$

$while(i < n)$:

    $StringBuilder\ temp \leftarrow ""$

    $l = 0$

    $while(l < rs.length())$:

        $r = l + 1$

        $while(r < rs.length()\ \&\ rs[l] == rs[r]): r \leftarrow r + 1$

        $count = r - l$

        $temp.append(count)$

        $temp.append(rs[l])$

        $l = r$

    $rs = temp$

    $i \leftarrow i + 1$

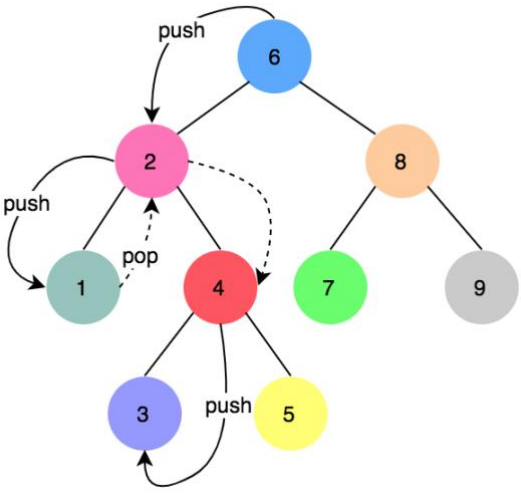
$return\ rs$

---

463. Island Perimeter

94. Binary Tree In-order Traversal Microsoft

Non-recursive Solution



$re = \{\phi\}$

```
Stack[TreeNode] st = {ϕ}
TreeNode node := root
while(node ≠ nil):
    st.push(node), node := node.left
while(st.size > 0):
    node := stack.pop
    re.add(node.val)
    if(node.right ≠ nil):
        node := node.right
        while(node ≠ nil):
            stack.push(node)
            node := node.left
return re
```

202. Happy Number

217. Contains Duplicate

219. Contains Duplicate II

```
for(int x: nums)
    if(set.contains(x)): return true
    set.add(x)
return false
```

Find if there exists 2 indexes $i, j, j - i \leq k, nums_i == nums_j$

```
map(int: int)
for(int i = 0; i < nums.length; )
    if(map[nums_i] ≠ null):
        index ← map[nums_i]
        if(i − index ≤ k): return true
    map[nums_i] = i
return false
```

83. Remove Duplicates from Sorted List & II (82)

```
ListNode deleteDuplicates(ListNode head)
    if(head == null):return null
    ListNode p ← head
    while(p ≠ null):
        if(p.next == null):break;
        ListNode q ← p.next
        while(q ≠ null & q.val == p.val):q ← q.next
        p.next ← q
        p ← q
    return head
```

II. Remove all duplicated number only remain single number

```
ListNode deleteDuplicates · 2(ListNode head)
    ListNode dummy ← new ListNode(−1)
    dummy.next ← head
    ListNode p ← dummy, q = dummy.next
    while(q ≠ null):
        while(q.next ≠ null & q.next.val == q.val) q = q.next
        if(p.next == q):
            p = p.next, q = q.next
        else:
            p.next = q.next
            q = p.next
```

242. Valid Anagram

```
count(type = array, size = 26, default = 0)
if(s.length() ≠ t.length()):return false
for(i = 0 → s.length() − 1):
    counter[s[i]]+= 1
    counter[t[i]]−= 1
```

```
for(i = 0 → 25):
    if(counter[i] ≠ 0): return false
return true
```

---

147. Insertion Sort List

148. Sort List

```
ListNode sortList(ListNode head):
    if(head == nil or head.next == nil): return head
    ListNode prev = nil, slow = head, fast = head
    while(fast ≠ nil and fast.next ≠ nil):
        prev = slow
        slow = slow.next
        fast = fast.next.next
    prev.next = nil ⋆ very important, to cut down one list into two halves
    ListNode left = sortList(head)
    ListNode right = sortList(slow)
    return merge(left, right)

merge(left, right):
    ListNode head = (−1), r = head
    while(left ≠ nil and right ≠ nil):
        if(left.val ≤ right.val):
            r.next = left, r = r.next
        else: r.next = right, r = r.next
    while(left ≠ nil): r.next = left, left = left.next, r = r.next
    while(right ≠ nil): r.next = right, right = right.next, r = r.next
    return head.next
```

---

387. First Unique Character in a String

```
for(i = 0 → str.length − 1):
    counter[str[i] − 'a'].freq+= 1
    if(counter[str[i] − 'a'].freq == 1): counter[str[i] − 'a'].firstIdx = i
for(i = 0 → 25):
```

$if(counter[i].freq = 1 \ \& \ counter[i].firstIdx < result)$:

$result = counter[i].firstIdx$

$return \ result$

---

290. Word Pattern I & II (291) Uber

Given a $Pattern$ and a string str, find if str follows the same pattern

---

$words[] \leftarrow str.split('\backslash s')$

$if(words.size \neq pattern.length): return \ false$

$map\langle char, string\rangle \ char2str$

$set\langle string\rangle \ visited$

$for(i = 0 \rightarrow pattern.length;)$:

$ch \leftarrow pattern[i]$

$ss \leftarrow words[i]$

$if(char2str[ch] \neq \ nil \ \& \ char2str[ch] \neq ss): return \ false$

$if(char2str[ch] \ is \ nil \ \& \ visited[ss] \ is \ null): return \ false$

$char2str[ch] \rightarrow ss$

$visited.add(ss)$

---

205. Isomorphic Strings

Q. check two strings s & t are isomorphic strings

Solution: like solution of 290 & 291, use hash-map & hash-set

---

$map = array_{1d}(int, default = 0)$

$visited = array_{1d}(boolean, default = false)$

$for(i = 0 \rightarrow s.length() - 1)$:

$if(map[s_i] \neq null \ \& \ map[s_i] == t_i): return \ false$

$if(map[s_i] == null \ \& \ !visited[t_i]): return \ false$

$map[s_i] = t_i$

$visited[t_i] = true$

II. No empty space between words in a string

Solution: DFS, time $O(n * (n-1) * \cdots * 1 = n!, n \ factorial)$

$boolean \ wordPatternMatch(pattern, str)$:

$if(pattern.length \ is \ 0 \ \& \ str.length \ is \ also \ 0): return \ true$

```
    if (pattern.length is 0): return false
    map<char, str> char2str, set<str> vis
    return check(pattern, 0, str, 0, char2str, vis)

boolean check(pattern, i, str, j, char2str, vis):
    if (i == pattern.length): return j == str.length
    for(k = j + 1 → str.length):
        substr ← str.substring(j, k)
        if (char2str[pattern[i]] ==  nil & vis[substr] == nil):
            char2str[pattern[i]] ← substr
            vis.add(substr)
            if (check(pattern, i + 1, str, k, char2str, vis)):
                return true
            char2str[pattern[i]] ← nil
            vis.remove(substr)
        elif (char2str[pattern[i]] ≠  nil & char2str[pattern[i]] == substr):
            if (check(pattern, i + 1, str, k, char2str, vis)):
                return true
    return false
```

---

66. Plus One

369. Plus One Linked List **Google**

Idea: reverse the linked list, plus one on first node and do carry-over on each node whose value exceeds 10, finally reverse the linked list again.

https://github.com/fu11211129/Algorithm/blob/master/list/google/PlusOneLinkedList.java

169. Majority Element **Zenefits** **Adobe**

Solution: voting algorithm.

```
re := A[0], freq := 1
for(i = 1 → len(A) − 1):
    if (A[i] = re): freq := freq + 1
    else: freq := freq − 1
    if (freq = 0): re = A[i], freq := 1
```

$return\ re$

86. Partition List

88. Merge Sorted Array Facebook Microsoft Bloomberg

Given two sorted integer arrays A and B, merge B into A as one sorted array.

Intuition

Scan from the back

$merge(int[\ ]\ A, m, int[\ ]\ B, n)$:

$i = m - 1, m \coloneqq m - 1, n \coloneqq n - 1$

$while(m \geq 0\ \&\ n \geq 0)$:

$if\,(A[m] \geq B[n]): A[i] \coloneqq A[m], i \coloneqq i - 1, m \coloneqq m - 1$

$else: A[i] \coloneqq B[n], i \coloneqq i - 1, n \coloneqq n - 1$

$while(n \geq 0): A[i] \coloneqq A[n], i \coloneqq i - 1, n \coloneqq n - 1$

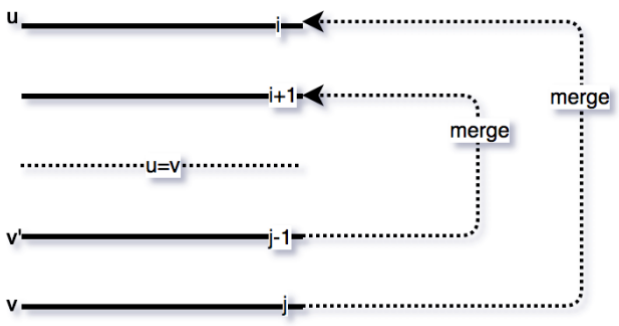
---

23. Merge k Sorted Lists Facebook

Intuition

Initialize two pointers, one points to the first list, another point to the last one. Each time merge two lists together into first one.

Algorithm #1



$$\frac{k}{2} * 2n + \frac{k}{4} * 4n + \cdots + \frac{k}{2^c} * (2^c n) = O(log\ k * kn)\,, n = \frac{\sum_{i=0}^{k-1} list[i].size}{k}$$

$u = 0, v = list.length - 1$

$while(u \neq v)$:

    $i = u, j = v$

    $while(i < j)$:

        $list[i] = merge(list[i], list[j])$

        $i \leftarrow i + 1, j \leftarrow j - 1$

    $v = j$

$return\ list[0]$

Algorithm #2

Min Heap, Time Cost: $O(log\ k \star kn)$ & Space Cost: $O(nk)$

412. Fizz Buzz

$result \leftarrow \{\phi\}$

$for(i = 1 \rightarrow n)$:

    $if(mod(i, 3) == 0\ \&\ mod(i, 5) \neq 0): result.add('fizz')$

    $elif(mod(i, 3) \neq 0\ \&\ mod(i, 5) == 0): result.add('buzz')$

    $elif(mod(i, 15) == 0): result.add('fizzbuzz')$

    $else: result.add((char)(i + '0'))$

---

758. Bold Words in String Google

Solution I: $Time\ complexity: O(n \star m \star k), m = dict.size, k = avg(word[i].length)$

$its(Interval) = \{\}$

$for(i = 0 \rightarrow n - 1)$:

    $for(word: dict)$:

        $if\big(s.startsWith(word, i)\big): its.add\big(new\ Interval(i, i + word.length - 1)\big)$

$its = merge \cdot intervals(its)$

$for(Interval\ it: its)$:

    $for(i = it.start \rightarrow it.end): bold[i] = true$

$for(i = 0 \rightarrow n - 1)$:

    $if\big(bold[i]\ and\ (i == n - 1\ or\ !bold[i + 1])\big): result \leftarrow result + "\langle/b\rangle"$

    $result \leftarrow result + s_i$

    $if\big(bold[i]\ and\ (i == n - 1\ or\ !bold[i + 1])\big): result \leftarrow result + "\langle/b\rangle"$

$return\ result$

Optimization: since for real English words, there is no word with a length greater than 10, so we do not need to get all substring of $s[i:j]$, instead, just need to retrieve the $s[i:i] \to s[i:i+9]$, then the time complexity can be reduced from $O(n^3) \to O(nL^2)$ where $L = \max\big(len(word_i)\big)$

$for(i = 0 \to n-1)$:
    $for(l = \min(n-i, kMaxWordLen = 10) \to 1)$:
        $if\big(dict\big[s_{i,l}\big] \neq null\big)$:
            $for(k = i \to i+l): bold[k] = true$