BQ

Describe a time you encountered an issue and how you fixed it.

You may want to ask back things like:

Are you talking about a technical issue, or management issue?

Is there some specific type of issue you are looking for?

Example Answer: When my team and I did the master program project, I was assigned to do information retrieve of data source, this is a kind of open-mined problem, and there are several potential approaches to this problem, so, I created a demo and quickly test most of the techniques (velocity). I managed to solve this problem with several techniques like NLP. But it did not give the result as we expected. And it seems all possible techniques have been tried (agile). So, I decided to approach this problem in a different way, Later, I found I may take this issue too complicated, I report this issue to my team (good team player), and we found there is no need to know the ground truth of each data package, we just need to know how one data piece is related to another. I it is just one kind of un-supervised learning problem, after we transfer the focuses, we quickly found a simple machine learning model which can best solve the problem.

Describe a time you made a mistake

Briefly describe the mistake (S/T), while most focuses on the (lesson you have learned) from it. Discuss (the approach) to solve the problem and have a happy ending.

When I was new to my company, I accepted two simultaneous projects from two managers. I didn't want to seem like I couldn't handle the work, so I didn't tell either one that I had another project. When the deadlines for one project unexpectedly changed, I couldn't meet the deadlines for both. I admitted the issue to my managers, and one of them brought on another employee to help meet the accelerated deadlines. I now keep my managers updated on potential issues and assess what I can handle more realistically.

How to solve conflicts within a team

Once our team was asked to design a website, but my teammates have different opinions about the implementation, so I decided to gather each one's perspective, and came out a plan which can be accepted by all of us. And finally, the project is done in an efficient way, everyone has contributed something into it.

Describe a challenge Uber

Technical challenge

Learning intricacies of a new software within the stipulated time of a project.

Often you are put on a project where you have, say, 6 months to execute it but the technology you'll be working on is not your area of expertise and then you should spend time learning it within a month or so. This is particularly tough, especially when you are dealing with several unique concepts all at once.

Management challenge

Working with teams spread out globally.

Working with such teams (that work in different time zones) involves hand-offs at the end of your shift and beginning of their shift. You must explain things ranging from business requirements, design decisions and development decisions to details of coding, modularization, unit test cases within a short couple of hours. If you are not working with an experienced team (both onsite and offsite), then this communication will most likely be of poor quality resulting in the exchange being meaningless and ultimately wasting one full offsite working day and one full onsite working day.

Data Structure & System Design

Design Uber Uber

Scenario Analysis:

Phase I: Driver reports locations, rider request an uber, match driver with riders.

driver either accept or deny the request;

*Driver can cancel a matched request;*

Rider can cancel a request;

Driver picks up a rider and starts the trip;

Driver drops off a rider and end the trip

Phase III: Uber pool & Eat

QPS Analysis:

About 0.2M drives in the U.S, each driver reports his location once four seconds, thus the drive's QPS is 0.2M * 0.25 = 50K, and the peak QPS is 50K * 3 = 150K. As for the rider's QPS is far less than driver's QPS.
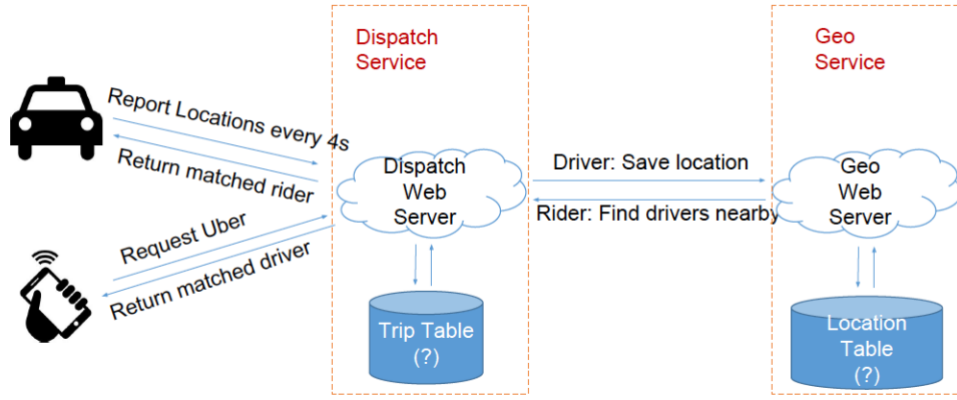
SQL Schema

$$trip \begin{cases} uid(pk, int) \\ rider \cdot id(fk, int) \\ driver \cdot id(fk, int) \\ latitude(float) \\ longitude(float) \\ status(wait, pickup, arrived) \\ created \cdot at(ts) \end{cases} \qquad location \begin{cases} driver \cdot id(fk) \\ latitude(float) \\ longitude(float) \\ created \cdot at(ts) \end{cases}$$

For Uber rider, it firstly checks if a matched driver exists in trip table through Dispatch Service,

select driver · id from trip where rider · id = ***

if such a driver doesn't exist, then forward this request to Geo Service, and find near-by drivers.

select driver · id from trip where geohash(location) like ***

Once Dispatch Service got the data, it will update such information into trip table,

insert into trip(⋯, rider · id, driver · id, ⋯) values(⋯,*,*,⋯)

As for Uber driver, it continuously updates its location in the location table,

update location set latitude = *, longitude = * where driver · id = *

Also, Uber driver will always keep an eye on trip table through Dispatch Service, it there is an matched trip, the driver will takes the order and update information from trip table
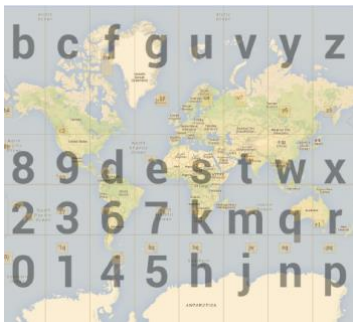
select driver · id from trip where driver · id = *

$update\ trip\ set\ status =' pickup'\ where\ driver \cdot id = *$

NoSQL Schema

$row_{key} = (driverId)$

$column_{key} = (geohash)$

How to find near-by driver

Candidate solution: convert (latitude, longitude) into base32[0-9a-z^abc]* hash-code, it goes like the following picture:

As the left picture suggests, the whole area will be divided into 32 cells, and each cell will be furtherly divided into 32 cells. For example,

- *LinkedIn HQ*: $9q9hu3hhsjxx$
- *Google HQ*: $9q9hvu7wbq2s$
- *Facebook HQ*: $9q9j45zvr0se$

$SQL\ query: select * from\ location\ where\ geohash\ like\ '9qhu'$

NoSQL(Cassandra): $set\ geohash\ to\ be\ the\ column\ key, apply\ range\ query$

NoSQL(Redis/Memcached, KV store[1]): $hierarchic\ storage, for\ example:$

$'9qhu' \rightarrow' 9h9uvt'$

$'9qhuv' \rightarrow' 9h9uvt'$

$'9qhuvt' \rightarrow' 9h9uvt'$

In general, 6-bits long geo-hash code is accurate to 1km, which is accurate enough for real use.

DB Sharding

Sharding with city (apportion the querying traffic & avoid single-point failure)

City can be presented as polygon, and determine in which city a driver locates is the problem of determine one point locate in one of the polygons.

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.

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[1] http://www.allthingsdistributed.com/files/amazon-dynamo-sosp2007.pdf

release: Recycle or release a number.

$Stack\langle int\rangle\ released$

$boolean[]\ used$

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

$get():$

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

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

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

        $return\ phone \cdot number$

    $else:$

        $if(index < maxnumber):$

            $used[index] = true$

            $index = index + 1$

            $return\ index - 1$

        $else: return - 1$

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

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

    $used[phone \cdot number] = false$

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

MapReduce

Normally, 1TB – 10TB file be "large" file, the number of "map" and "reduce" machines approximate to 1K.

Scenario I: Word Count on a File.

Solution I: $map\langle string, int\rangle\ word \cdot count$

Solution II: MapReduce, a distribution calculation framework

5 Steps: Input, Split, Map (external sort & partition), Reduce (fetch & merge sort) & Output

Supposing there is a 1TB file to be counted, and single machine cannot take the whole job.

Split, so we manage 1K "map" machines working on counting words of the 1GB file $(f_0, f_1, \cdots, f_{999})$. So, each machine works on 1GB sub-file.

Map, each machine does "map" (word → 1) on the 1GB sub-file, then sort all (key, value) pairs (those key, value pairs are stored in disk) using external sorting. Then we partition the sorted KV pairs into certain parts, say 26 (starting letter of word) parts. So

$$f_i = [f_i^a(addr_i^a, offset_i^a), f_i^b, \cdots, f_i^z]$$

Reduce, supposing there are another 26 machines $r_a, r_b, \cdots, r_z$ work on the "reduce" part, then r_i reads all chunks of $[f_0^i, f_1^i, \cdots, f_{999}^i \ for \ \forall i \in [a \to z]$. Next, we do k-path merge sort on machine r_i to merge $[f_0^i, f_1^i, \cdots, f_{999}^i]$. The intermediate output goes like:

$$hello: [1,1,1]$$
$$world: [1,1]$$
$$java: [1,1,1,1]$$

The final step of "reduce" is summarizing the above output into something like:

$$hello: [3], world: [2], java: [4]$$

External Sorting:

$step\ \mathrm{I}: split\ file\ into\ chunks\ [c_0, c_1, c_2, \cdots, c_{n-1}]$

$step\ \mathrm{II}: sorted\ those\ chunks\ respectively\ [c_{sorted}^0, c_{sorted}^1, \cdots, c_{sorted}^{n-1}]$

$step\ \mathrm{III}: merge\ those\ sorted\ chunks\ into\ new\ file$

Scenario II: Build Inverted Index with MapReduce

| a_0:"Dear Bear River"
a_1:"Car River"
a_2:"Dear Car Bear"
input | → | $Deer: 0, Bear: 0, River: 0$
$Car: 1, River: 1$
$Deer: 2, Car: 2, Bear: 2$
map | → | $Bear: 0, Bear: 2$
$Car: 1, Car: 2$
$Deer: 0, Deer: 2$
$River: 0, River: 1$
reduce | → | $Bear: 0,2$
$Car: 1,2$
$Deer: 0,2$
$River: 0,1$
output |

Interview Q: Find Top 10 relevant articles for given input word list

$maxheap(score, article_{id}), sorted\ by\ score$

$for(articel\ ar: article \cdot list):$

$\quad score = 0$

$\quad for(word\ w: ar.words \cdot collection):$

$$if\,(searched \cdot words[w] \neq null): score += 1$$

$$if\,(maxheap.size < 10\, ||\, score > maxheap.peek.score):$$

$$maxheap.offer(\langle score, articld_{id}\rangle)$$

Design WhatsApp

- $Real - time\ Service$
- $Online\ Status: Pull\ vs. Push$

Functionalities:

- $User\ Login\ \&\ Register$
- $Contact$
- $User\ Communication$
- $Group\ Chat$
- $User\ Online\ Status$

Database Table Design:

$$message(big, NoSQL) \begin{cases} meesage \cdot id \rightarrow (\boldsymbol{pk})\boldsymbol{user} \cdot \boldsymbol{id} + \boldsymbol{created} \cdot \boldsymbol{at} \\ \color{red}{thread \cdot id \rightarrow (\boldsymbol{fk})\ \boldsymbol{create} \cdot \boldsymbol{user} \cdot \boldsymbol{id} + \boldsymbol{timestamp}} \\ user \cdot id \rightarrow who\ send\ the\ meesage \\ content \rightarrow message\ body \\ created \cdot at \rightarrow when\ the\ message\ was\ sent \end{cases}$$

$$thread(SQL) \begin{cases} own \cdot id \rightarrow uid(\boldsymbol{pk}, \boldsymbol{indexed}) \\ \color{red}{thread \cdot id \rightarrow int(\boldsymbol{pk}, \boldsymbol{create} \cdot \boldsymbol{user} \cdot \boldsymbol{id} + \boldsymbol{timestamp})} \\ participants \cdot id \rightarrow varchar(\boldsymbol{indexed}) \\ participants \cdot hash \rightarrow int \\ is \cdot muted \rightarrow int \\ created \cdot at \rightarrow timestamp \\ updated \cdot at \rightarrow timestamp \end{cases}$$

$$thread(SQL) \begin{cases} message[1] \\ message[2] \\ \cdots \qquad\qquad \text{(one thread may contain multiple messages)} \\ message[n-1] \\ message[n] \end{cases}$$

Multiple $own \cdot id$ may share multiple $thread \cdot id(s)$, so $(own \cdot id + thread \cdot id)$ uniquely identify a thread.

Workable Solution: when a client $user_a$ sends a message called "hello world" to $user_b$, this message will be forwarded to the server, and server created two rows in the database. (because

$user_a$ initialize the conversation, so $create \cdot userid = user_a$ and $thread \cdot id = user_a + 1225$, where 1225 is the timestamp), so such two rows go like these:

$(user_a, user_a + 1225, [user_a, user_b], hash(user_a, user_b), false, 1225, 1225)$

$(user_b, user_a + 1225, [user_a, user_b], hash(user_a, user_b), false, 1225, 1225)$

After the updates in the $thread$ table finished, it updates a row in $message$ table $(user_a + 1225, user_a + 1225, user_a, hello\ world, 1225)$.

As for the $user_b$, he checks if there is any new thread or message comes in by requesting from server. If it is the first-time conversation between $user_a$ & $user_b$, then the server first retrieves the data from $thread$ table using such query: $select * from\ thread\ where\ own \cdot id = \cdots$. At this stage, on the client side of $user_b$, a thread between $user_a$ & $user_b$ will be created, then retrieve the data from $message$ table using the $thread \cdot id$.
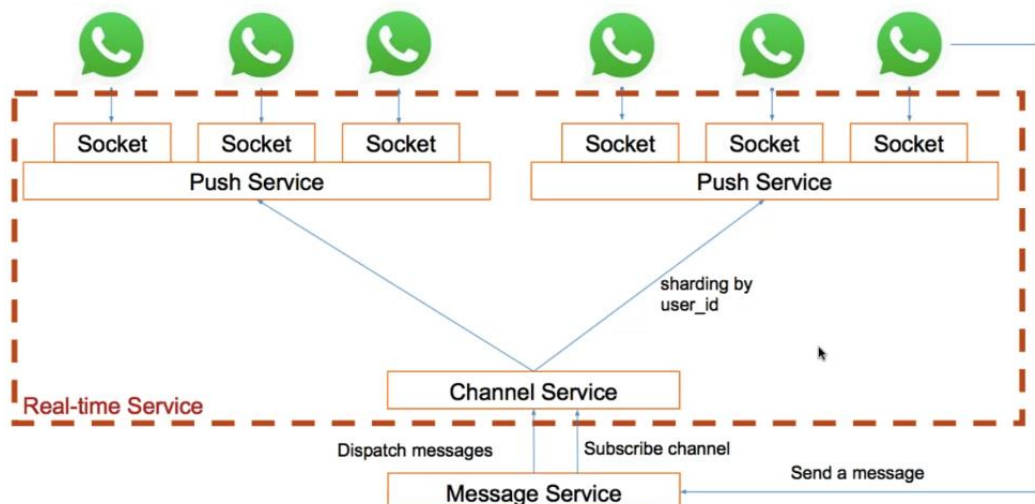
Storage:

$set\ thread \cdot id\ as\ the\ row\ key(sharding\ key)\ for\ table\ 'message'$

$set\ user \cdot id\ as\ the\ (sharding\ key)\ for\ table\ 'thread'$

Large Group Chat

$add\ an$ channel$s\ service,$

channel service keeps track of Push Servers & Active User per Push Server.

By doing so, in case in a group chat consisting of 500 people, if only 10 users still active, there is no need for having all push servers to push message back to all 500 users. With the help of "channel service", we can easily target the one or several of push servers correspond to the 10 users. It can solve time from for-loop pushing message.

Design Twitter

Scenario: Daily Active User (DAU): 150M

Functionalities:

Login & signup

Post a tweet

Timeline/ newsfeed

Follow & unfollow a user

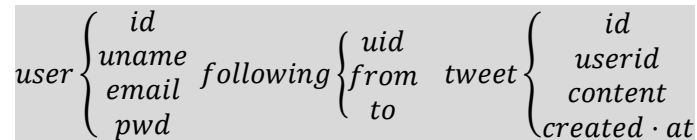**Read & Write QPS:**

Suppose each user make 60 read requests per day, so the read QPS is $\frac{150M*60}{86400} \approx 100k$ and the peak QPS is $100k * 3 = 300k$ and suppose each user post a tweet per day, so the write QPS is $\frac{150M*1}{86400} \approx 5k$

Pull Model

$$user \begin{cases} id \\ uname \\ email \\ pwd \end{cases} following \begin{cases} uid \\ from \\ to \end{cases} tweet \begin{cases} id \\ userid \\ content \\ created \cdot at \end{cases}$$

$get \cdot newsfeed(request)$

    $followings = DB.getFollowings(request.user)$

    $news \cdot feed = \{\phi\}$

    $for\ follow\ in\ followings:$

        $tweets = DB.getRecentTweets(follow.user, 100)$

        $news \cdot feed.merge(tweets)$

    $sort(news \cdot feed)$

    $return\ news \cdot feed$

$post \cdot tweet(request, tweet)$

    $boolean\ success = DB.insertTweet(request.user, tweet)$

    $return\ success$

Push Model:

If Tom posts a tweet "hello world", Tom has three friends Bob, Jerry & Vivian, then four copies of "hello world" will be inserted into newsfeed table.

$$user \begin{cases} id \\ uname \\ email \\ pwd \end{cases} \quad following \begin{cases} uid \\ from \\ to \end{cases} \quad tweet \begin{cases} id(p.k) \\ userid \\ content \\ created \cdot at \end{cases} \quad newsfeed \begin{cases} id \\ ownid \\ tweet \cdot id(f.k) \\ created \cdot at \end{cases}$$

$get \cdot newsfeed(request)$

    $tweet \cdot ids = DB.getNewsfeed(request.user(ownid))$

    $select\ content\ from\ tweet\ where\ id\ in\ (tweet \cdot ids)$

$post \cdot tweet(request, tweet)$

    $tweet \cdot id = DB.insertTweet(request.user, tweet)$

    $AsyncService.fanoutTweet(request.user, tweet \cdot id)$
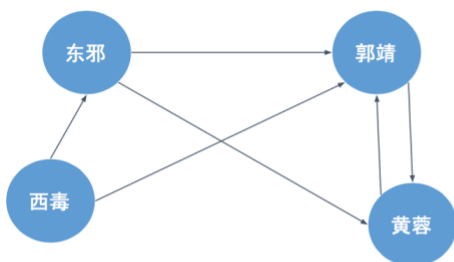
    $return\ success$

$AsyncService :: fanoutTweet(request.user, tweet)$

    $fans = DB.getFollowers(user)$

    $for\ fan\ in\ fans:$

        $DB.insertNewsFeed(fan, tweet)$

东邪西毒，郭靖黄蓉的好友关系如下：

东邪发了一条帖子："好想念超风"
西毒发了一条帖子："好想念嫂子"
郭靖发了一条帖子："不知道华筝怎么样了"
黄蓉发了一条帖子："男人都不是好东西"

	News Feed Table		
id	owner_id	tweet_id	created_at
1	东邪	东邪:好想念超风	2016/10/15 16:30:00
2	西毒	东邪:好想念超风	2016/10/15 16:30:00
3	西毒	西毒:好想念嫂子	2016/10/15 16:35:00
4	郭靖	郭靖:不知道华筝怎么样了	2016/10/15 17:00:00
5	东邪	郭靖:不知道华筝怎么样了	2016/10/15 17:00:00
6	西毒	郭靖:不知道华筝怎么样了	2016/10/15 17:00:00
7	黄蓉	郭靖:不知道华筝怎么样了	2016/10/15 17:00:00
8	黄蓉	黄蓉:男人都不是好东西	2016/10/15 18:00:00
9	郭靖	郭靖:男人都不是好东西	2016/10/15 18:00:00
10	东邪	郭靖:男人都不是好东西	2016/10/15 18:00:00

黄蓉登陆"射雕APP"之后可以看到的所有帖子通 过一句 SQL 查询可以拿到：
select * from news_feed_table where owner_id=黄蓉 order_by created_at desc limit 20;

Design Garbage Collection

Strategy I: Naïve mark & sweep (stop-the-world GC)

$objects\ poll \rightarrow op\{o_1, o_2, \cdots, o_n\}$

$graph\ g \leftarrow empty$

$for(object\ o_x\ in\ op):$

    $for(object\ o_{xi}\ referenced\ by\ o_x)$

$$insert\ directed\ edge: \{o_x \rightarrow o_{xi}\}\ into\ g$$

then do a tree traversal following object references and mark all the visited objects.

The disadvantage of this algorithm is that the entire system must be suspended during garbage collection.

Strategy II: Reference Counting

For each of objects, associated it with an extra field, called referenced count, in case one object has 0 reference count, meaning this object should be recycled.

Disadvantage: space & time overhead

Strategy III: Triple Color Marking

$$Gray = \{O_{gray}, O_{gray} \in root's\ references\}$$
$$White = \{O_{white}, O_{white} \notin root's\ references\}$$
$$Black = \{\phi\}$$

$$while(gray. is\ not\ empty):$$
$$\quad O_{gray} = gray. pop()$$
$$\quad Black. add(O_{gray})$$
$$\quad for(O_{white} \in White\ \&\ O_{white}\ is\ referenced\ by\ O_{gray}):$$
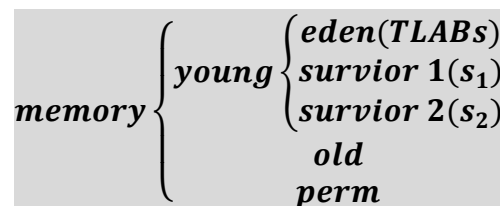$$\quad\quad Gray. add(O_{white})$$
$$\quad\quad White. pop(O_{white})$$

In the final stage, Gray is empty and recycle all "White" objects

Java GC

Java memory is divided into three main blocks according to the alive time of objects, those three blocks are called Young, Old & Permanent

$$memory \begin{cases} young \begin{cases} eden(TLABs) \\ survior\ 1(s_1) \\ survior\ 2(s_2) \end{cases} \\ \quad old \\ \quad perm \end{cases}$$

$$O_{new} = new\ Object$$
$$if(eden\ can\ accomondate\ O_{new}):$$

$$eden.place(O_{new})$$

$else$

$\quad if(s_1 \text{ or } s_2 \text{ can accomondate } O_{new}):$

$$\quad\quad s_{1|2}.place(O_{new})$$

$\quad else: apply \text{ } mark \text{ } \& \text{ } copy \text{ } algo \text{ } on \text{ } s_1 \text{ } or \text{ } s_2$

$\quad if(O_{new} \text{ } still \text{ } alive \text{ } after \text{ } 15 \text{ } recycle \text{ } rounds): swap \text{ } O_{new} \rightarrow old \text{ } generation$

Serial GC, Parallel GC, CMS (Concurrent Mark & Sweep) and Garbage First

Serial GC, apply stop-the-world mark & copy algorithm on Young & Old Generation.

CMS: Concurrent Mark & Sweep,

355. Design Twitter

$map\langle Integer, Set\langle Integer\rangle\rangle \text{ } fans$

$map\langle Integer, Tweet\rangle \text{ } tweets$

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

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

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

$\quad result \leftarrow new \text{ } list\langle Tweet\rangle$

$\quad for(friend \text{ } f: friendlist):$

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

$\quad\quad if(tw \text{ } is \text{ } not \text{ } nil): pq.offer(tw)$

$\quad count \leftarrow 0$

$\quad while(!pq.empty \text{ } \& \text{ } count < 10):$

$\quad\quad Tweet \text{ } top = pq.poll()$

$\quad\quad result.add(top)$

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

$\quad\quad count \leftarrow count + 1$

146. LRU Cache Facebook Uber

$$Node \begin{cases} key \\ val \\ prev \\ next \end{cases} \rightarrow d\ell\ell \begin{Bmatrix} head \\ tail \end{Bmatrix}$$

```
int get(K):
    if(keyNode[K] ≠ nil):
        node := keyNode[K]
        V := node.val
        dℓℓ.unlink(node)
        dℓℓ.addHead(node)
        return V
    return − 1


void set(K, V):
    if(keyNode[K] ≠ nil):
        node := keyNode[K], node.val := V
        dℓℓ.unlink(node), dℓℓ.addHead(node)
    else:
        if(keyNode.size < cap):
            new := (K, V)
            dℓℓ.addHead(new)
            keyNode[key] := new
        else:
            ℓru := dℓℓ.tai.prev
            dℓℓ.unlink(ℓru)
            keyNode[ℓru.key] = nil
            new := (K, V)
            dℓℓ.addHead(new)
            keyNode[key] := new
```

Follow Up: Distributed LRU Uber

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

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

$microShardNum = 1k$

$shard2MachineId = \{\phi\}$

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

    $count = 0$

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

    $while(count < microShardNum):$

        $rid = rand.nextInt(shardNum)$

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

            $shard2MachineId[rid] = machine_{id}$

            $count = count + 1$

            $group.add(rid)$

    $for(int\ id: group):$

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

$int\ getMachineByHash(int\ hashId):$

    $i = hashId$

    $while(true):$

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

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

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

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

    $machine_{id} \leftarrow getMachineByHash(hid)$
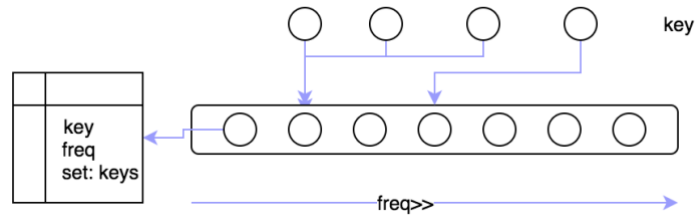
    $update(machine_{id}, source, value)$

$V\ request(K\ resource):$

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

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

$$request(machine_{id}, K)$$

460. LFU Cache Google Amazon

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:

$$if\,(map.size > cap): removeOld()$$

$$key2value.put(key, value)$$

$$increase(key)$$

$$void\ increase(int\ key):$$

$$Node\ nd \leftarrow key2node[key]$$

$$if\,(nd \neq nil):$$

$$nd.keys.remove(key)$$

$$if\,(nd.next == dll.tail\ or\ nd.next.freq \neq nd.freq + 1):$$

$$Node\ nx \leftarrow Node(key, nd.freq + 1)$$

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

$$key2node.put(key, nx)$$

$$elif\,(nd.freq + 1 == nd.next.freq):$$

$$nd.next.keys.add(key)$$

$$key2node.put(key, nd.next)$$

$$if\,(nd.keys.size == 0): remove(nd)$$

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

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

$$nd.keys.add(key)$$

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

$$key2node.put(key, nd)$$

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

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

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

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

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

$$int\ tobeRemoved := nil$$

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

$$tobeRemoved \leftarrow k, break$$

$$key2value.remove(tobeRemoved)$$

$$key2node.remove(tobeRemoved)$$

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

432. All O'one Data Structure Uber

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

Intuition & Algorithm

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

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

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

$Solution\ \text{I}: ArrayList + hashmap$

$list\langle int\rangle\ list$

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

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

$delete(int\ val):$

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

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

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

$boolean\ insert(int\ val):$

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

$\quad val_{\to index}[val] \leftarrow count$

$\quad index_{\to val}[count] \leftarrow val$

$\quad count \leftarrow val_{\to index}.\,size$

$boolean\ delete(int\ val):$

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

$\quad idx \leftarrow val_{\to index}[val]$

$\quad val_{\to index}[val] \leftarrow null$

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

$\quad\quad lastvalue = index_{\to val}[count - 1]$

$$index_{\to val}[idx] \leftarrow lastvalue$$

$$val_{\to index}[lastvalue] \leftarrow idx$$

$$else: index_{\to val}[idx] \leftarrow null$$

$$count \leftarrow val_{\to index}.size$$

Design Rate Limiter Google Uber

For example, no more than 100 requests per second.

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

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

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

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

$check\ sum\ is\ in\ limitation$

$interface\ RateLimit\ \{$

    $void\ setQPS(int\ qps);$

    $boolean\ allowThisRequest()$

$\}$

$public\ class\ RateLimitImpl\ implements\ RateLimit\ \{$

    $private\ long\ qps_{ms}$

    $private\ Map\langle ip, Queue\langle int\rangle\rangle\ map$

    $public\ void\ setQPS(int\ qps):$

        $if(qps < 1\ or\ qps > 1million): throw\ new\ RunException()$

        $qps_{ms} = qps * 1k$

        $map \leftarrow new\ HashMap\langle\rangle$

    $public\ boolean\ allowThisRequest(Request\ req):$

        $boolean\ allowed \leftarrow false$

        $Q = map.getOrDefault(req.ip, new\ Queue\langle\rangle())$

        $if(Q.isEmpty()):$

            $Q.offer(req)$

        $elif(Q.size() < qps_{ms}\ ||\ req.ts - Q.peek() > 1000_{ms}):$

            $allowed = true$

$$while(Q.size() > 0 \ \& \ req.ts - Q.peek() > 1000_{ms}): Q.poll()$$

$$else: allowed = false$$

$$return \ allowed$$

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.

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

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

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

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

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

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

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

359. Logger Rate Limiter Uber

$boolean \ shouldPrintMessage(String \ msg, int \ ts):$

   $if \ (map[msg] == null \ || \ ts - map[msg] \geq 10s):$

     $map[msg] = ts$

     $return \ true$

   $return \ false$

636. Exclusive Time of Functions Facebook Uber

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

$int[\ ]\ result\ =\ new\ int[n];$

$Stack\langle int\rangle\ stack\ =\ new\ stack <> ();$

$int\ prev\ =\ 0;$

$for(String\ log:logs):$

    $String[\ ]\ token\ =\ log.split(":");$

    $int\ funcId\ =\ Integer.parseInt(token[0]);$

    $boolean\ start\ =\ token[1].equals("start");$

    $int\ ts\ =\ Integer.parseInt(token[2]);$

    $if(start):$

        //calculate outer function time cost

        $if(!\,stack.empty):re[stack.peek]\ +=\ ts\ -\ prev;$

        $stack.push(funcId);$

        $prev\ =\ ts;$

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

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

        $prev\ =\ ts\ +\ 1;$

$return\ result;$

Design PokemonGo. <mark>Uber</mark>

http://www.1point3acres.com/bbs/thread-287893-1-1.html

Design Type-head <mark>Uber</mark>

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

$req \leftrightarrow \boxed{\begin{matrix} QueryServices \\ (trie) \end{matrix}} \leftrightarrow \boxed{\begin{matrix} Data\ Collection \\ (word, freq) \end{matrix}} \underset{ask\ search\ data\ once\ a\ week}{\overset{\longleftrightarrow}{\longrightarrow}} search\ logs$
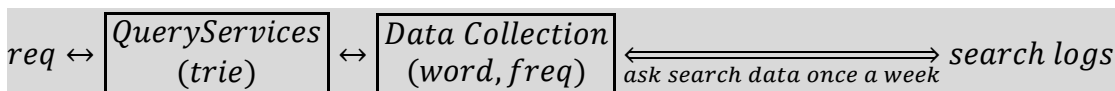
Workable solution: when user types a prefix, say *"am"* into google search textbox, it automatically makes a request to the *QueryServices*, and the *QueryServices* scan the *"am"* char by char in the Tire. At node of "m", there is a list of nodes, say *"amazon",*"amaze"*, etc.* which is associated with 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:

```sql
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.
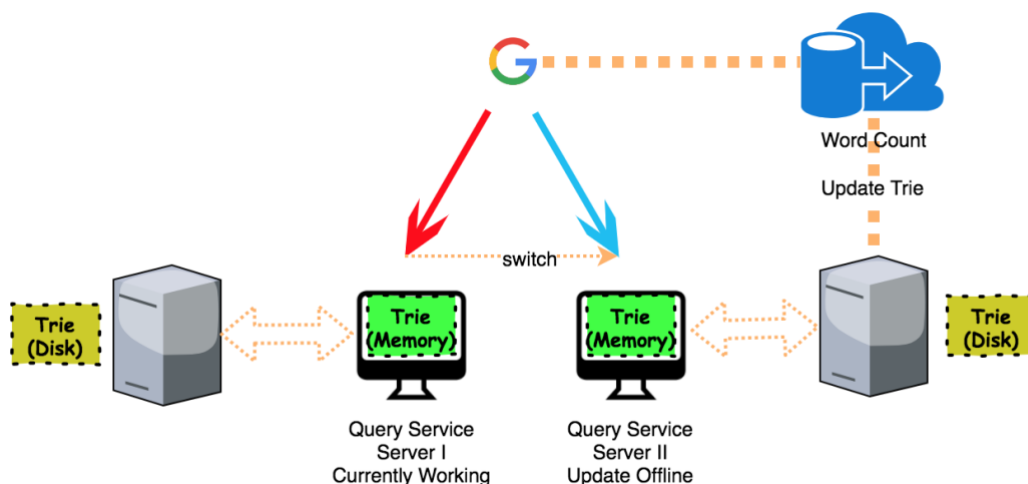
Scalability: hire multiple Query Service machine

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 Google

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

$while(p \neq null):$

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

 $p = p.next$

$return\ result.val$

398. Random Pick Index Facebook

$e := 1, re := -1$

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

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

$return\ re$

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 <mark>ForUsAll</mark>

making the all characters in ascending order after delete. For example, $str = \textbf{'banana'}$, 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.

$f[0,0] = true$

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

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

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

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

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

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 $f[i,j,v] \coloneqq f[i,j,v] + f[i-1,j,v]$o. Option #2, selecting the $(i-1)^{th}$ number, so $f[i,j,v] \coloneqq f[i,j,v] + f[i-1, j-1, v - A[i-1]]$

```
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 <mark>Uber</mark>

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 $1\ to\ i$.

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

```
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)
```
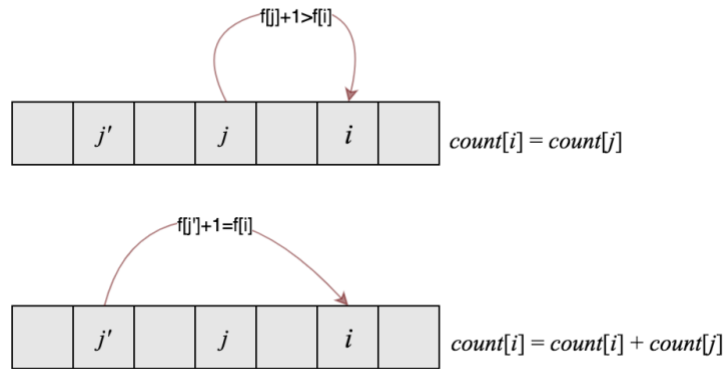
673. Number of Longest Increasing Subsequence Facebook

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.

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

$int[\,]\,counts := [n], counts[i] := 1$

$\mathcal{LIS} := 0$

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

    $mx := 1$

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

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

            $counts[i] := counts[j]$

            $mx := f[j] + 1$

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

            $counts[i] := counts[i] + counts[j]$

    $f[i] := mx$

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

$re := 0$

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

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

$return\ re$

---

10. Regular Expression Matching

Google Facebook Twitter Snapchat Two Sigma

Intuition & Algorithm

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

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

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

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

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

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

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

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

                $f[i,\jmath] := f[i,\jmath]\ ||\ (f[i-1,\jmath - 2]\ ||\ f[i-1,\jmath]\ ||\ f[i,\jmath - 2])$

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

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

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

            $f[i,\jmath] := f[i,\jmath]\ ||\ f[i-1,\jmath - 1]$

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

            $f[i,\jmath] := f[i,\jmath]\ ||\ f[i-1,\jmath - 1]$

---

97. Interleaving String Uber

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

Intuition & Algorithm

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

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

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

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

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

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

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

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

---

5. Longest Palindromic Substring Uber

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: $O(1)$

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

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

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

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

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

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

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

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

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

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

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

---

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 Facebook

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

Intuition & Algorithm

Binary-Search by initializing the range $\mathcal{L} := \min(A[i]), \mathcal{R} := \sum_0^{n-1} A[i]$. 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 $\mathcal{R} := mid - 1$. Otherwise, $\mathcal{L} := mid + 1$

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

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

$\quad \ell ong\ r := \sum_0^i A[i]$

$$re := r$$
$$while(l \le r):$$
$$\quad mid := \frac{l+r}{2}$$
$$\quad sum := 0, chunks := 1$$
$$\quad for(i = 0 \to n - 1):$$
$$\quad\quad if(sum + A[i] > mid):$$
$$\quad\quad\quad chunks := chunks + 1$$
$$\quad\quad\quad sum := A[i]$$
$$\quad\quad else: sum := sum + A[i]$$
$$\quad if(chunks \le m):$$
$$\quad\quad re := \min(re, mid)$$
$$\quad\quad r := mid - 1$$
$$\quad else: l := mid + 1$$
$$return \ (int) \ re$$

53. Maximum Subarray

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

Constant Space Solution

$$max \cdot here = A[0], re = A[0]$$
$$for(i = 1 \to A.length;):$$
$$\quad max \cdot here = \max(maxh \cdot here, 0) + A[i]$$
$$\quad re = \max(re, max \cdot here)$$

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

$$for(i = 0 \to k - 1): sum = sum + a[i]$$
$$presum = 0, premin = 0, re = sum$$
$$for(i = k \to n - 1):$$
$$\quad sum = sum + a[i]$$
$$\quad presum = presum + a[i - k]$$
$$\quad premin = \min(premin, presum)$$
$$\quad re = \max(re, sum - premin)$$

691. Stickers to Spell Word IXL

42. Trapping Rain Water

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

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.

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

$$for(k = 1; k \leq n;)$$
$$\quad \#0 = count \cdot zero(s[k]), \#1 = count \cdot one(s[k])$$
$$\quad for(i = m \rightarrow \#0):$$
$$\quad\quad for(j = n \rightarrow j \geq \#1):$$
$$\quad\quad\quad f[i,j] = max(f[i - \#0(s[k]), j - \#1(s[k])]) + 1$$

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.

$$for(i = 1 \rightarrow n):$$
$$\quad for(j = value(i - 1) \rightarrow total \cdot amount):$$
$$\quad\quad f[j] = min(f[j - values[i - 1]]) + 1$$

279. Perfect Square Google

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

$$int\ DP(int\ n, int[\ ]\ f):$$
$$\quad if(n = 0): return\ 0$$
$$\quad if(f[n] \neq nil): return\ f[n]$$
$$\quad for(v := 0 \rightarrow A[i]):$$
$$\quad\quad if(A[i] \leq v): f[i, v] := min(f[i, v], f[i - 1, v - A[i]] + 1)$$

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

$$bool[\ ]\ f = [len(s)]$$
$$for(i = 0 \rightarrow len(s) - 1):$$
$$\quad if(dict[s[0:i]] \neq nil):$$
$$\quad\quad f[i] = true, continue$$
$$\quad for(j = i - 1 \rightarrow 0):$$
$$\quad\quad if(dict[s[j + 1:i]] \neq nil\ \&\ f[j]): f[i] = true, break$$

$$re = [\phi]^{string}, cand = [\phi]^{string}$$
$$DFS(re, cand, dict, s, index)$$

$return\ re$

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

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

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

        $return$

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

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

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

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

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

131. Palindrome Partitioning

132. Palindrome Partitioning II

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

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

    $cut[i] := (palindrome[0, i] = True) \to 0 : i$

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

        $if(palindrome[pre + 1, i] = True) : cut[i] := \min(cut[i], cut[pre] + 1)$

        $cut[i] := \min(cut[i], cut[pre] + (i - pre))$

416. Partition Equal Subset Sum eBay

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

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

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

        $f[v] := f[v]\ ||\ f[v - A[i - 1]]$

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.
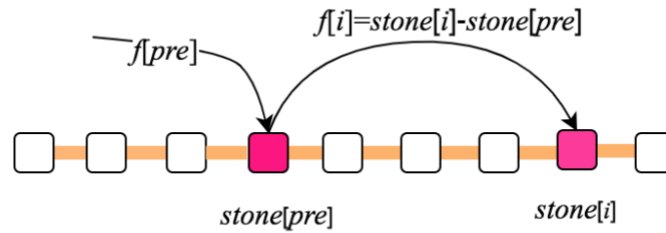
Intuition & Algorithm

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

$f[0] := 0, f[1] := 1$
$for(i = 2 \rightarrow n - 1):$
$\quad for(pre = 0 \rightarrow i - 1):$
$\quad\quad if(f[pre] < 0): continue \star$ *means this guy cannot make to pre*
$\quad\quad curstep := stone[i] - stone[pre]$
$\quad\quad if(f[i] = curstep \pm 1 \,||\, f[i] = curstep):$
$\quad\quad\quad f[i] := curstep$
$\quad\quad\quad break$
$return\ f[i] > 0 \rightarrow True: False$

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

$sort(A)$

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

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

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

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

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

    $Max := -2^{31}, maxj = -1$

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

        $if(A[i] \,\%\, A[j] = 0\ \&\ f[j] > Max):$

            $Max := f[j], maxj := j$

    $if(maxj \neq -1):$

        $pre[i] = maxj, f[i] = Max + 1$

$maxi := -1, max := -1$

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

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

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

$pos := maxi$

$Do: re.add(A[p]), p := pre[p]$

$while(p \neq -1)$

$return\ reverse(re)$

Stock Problem Series

121. Best Time to Buy & Sell Stock I

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

$return\ maxSumSubarray(dif)$

122. Best Time to Buy & Sell Stock II

Find all ascending subarray $prices[i{:}j]$ such that $prices[i] < \cdots < prices[j]$
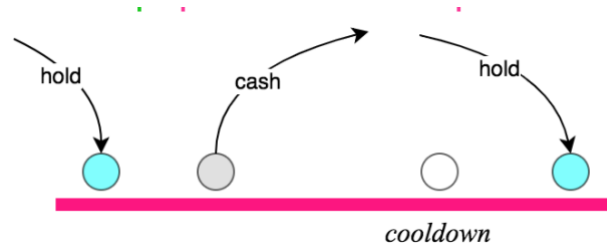
$$result := result + \sum_{i}^{j} prices[p]$$

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

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

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

    $temp \coloneqq hold$

    ⋆ either still hold when it's held at previous day,

    ⋆ or buy a new share of stock when previous day is cooldown day.

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

    ⋆ if today is cooldown day, then previous day must either be cooldown day or selling day

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

    ⋆ 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 ith 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.

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

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

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

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

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

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

$return\ cash$

Constant Space Optimization

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

⋆ *cash: max profit when no share of stock at hand*

⋆ *hold: max profit when holding a share of stock*

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

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

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

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

⋆ *buy current stock with prices[i]*

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

$return\ cash$

198. House Robber I LinkedIn Airbnb

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

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

$yes = A[0], no = 0, re := yes$

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

$temp := no$

$no = \max(yes, no)$

$yes = no + A[i]$

$re := \max(yes, no)$

$return\ re$

213. House Robber II (Rob in a Circle)

$re := \max(rob(A, 0, n-2), rob(A, 1, n-1))$

337. House Robber III (Rob in a BT)

$re := -2^{31}$

```
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.

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

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

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

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

$int[\ ][\ ]\,f := [n][n]$
$for(i = 0 \rightarrow n-1):$
  $for(j = 0 \rightarrow i): f[i,j] := 1$
$for(len = 2 \rightarrow n):$
  $for(i = 0 \rightarrow i + len \leq n):$
    $j := i + len - 1$
    $for(k = i \rightarrow j):$
      $if(k = i): f[i,j] := f[i,j] + f[k+1,j]$
      $elif(k = j): f[i,j] := f[i,j] + f[i,k-1]$
      $else: f[i,j] := f[i,j] + f[i,k-1] \star f[k+1,j]$

96. Unique Binary Search Trees II

$List\langle TreeNode\rangle\,dfs(l,r):$
  $if(l > r):\ return\ null$
  $List\langle TreeNode\rangle\,roots = \{\phi\}$
  $for(k = l; k < r;\ )$
    $List\langle TreeNode\rangle\,lchilds = dfs(l, k-1)$
    $List\langle TreeNode\rangle\,rchilds = dfs(k+1, r)$
    $for(TreeNode\ lc: lchilds):$
      $for(TreeNode\ rc: rchilds):$
        $TreeNode\ o = new\ TreeNode(nums[k])$
        $o.left = lc$
        $o.right = rc$
        $roots.add(o)$
$return\ roots$

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(r_1, c_1, r_2, c_2):
    for(c = c_1 → c_2):
        re ≔ re + colsum[c, r_2] − colsum[c, r_1] + mat[r_1, 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 ← l + ((r − l) ≫ 1)
    Node o ← new Node(l, r)
    o.left ← build(l, mid):
    o.right ← 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) ≫ 1)
    if(pos ≤ 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) ≫ 1)
    if(to ≤ mid): return querySum(o_left, from, to)
    elif(from ≥ mid): return querySum(o_right, from, to)
    else: return querySum(o_left, from, mid) + 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 := len(nums)
    int[] A := [N + 2]
    A[0] = A[N + 1] = 1
    for(i = 0 → len(nums) − 1): A[i + 1] = nums[i]
```

$$int[][] f := [N + 2][N + 2]$$

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

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

$$\quad\quad j := i + len - 1$$

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

$$\quad\quad\quad f[i, j] := f[i, j] + f[i, k] + f[k, j] + A[i] \star A[j] \star A[k]$$

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

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:

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

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

$$\quad len = 0$$

$$\quad for(int \; x: arr):$$

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

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

$$\quad\quad f[pos] = x$$

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

$$\quad return \; len$$

221. Maximal Square Facebook Apple Airbnb

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

674. Longest Continuous Increasing Subsequence Facebook

$$f[i] := f[i - 1] + 1, if \; A[i] = A[i - 1] + 1$$

$$f[i] := 0, otherwise$$

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

push
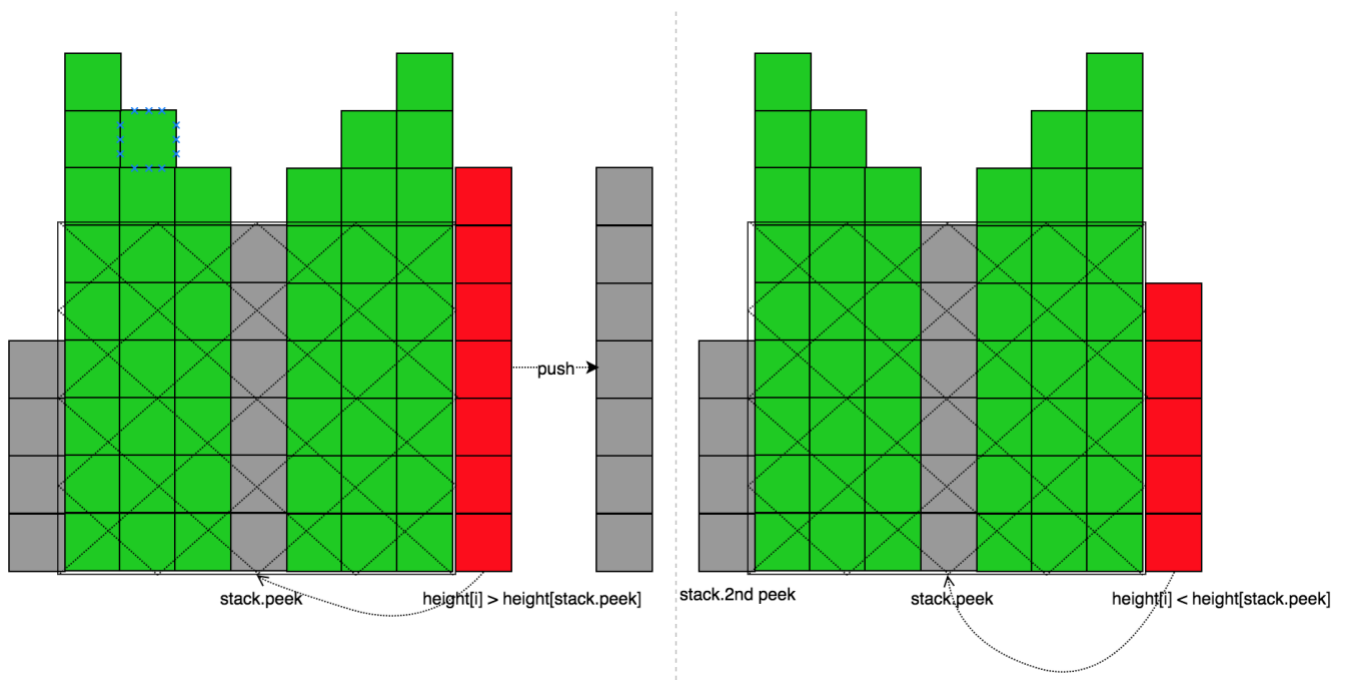
Intuition & Algorithm

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:

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

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

    $re := 0, st := Stack$

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

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

        $height := (i = \hbar.length) \to -1: \hbar[i] \Rightarrow \mathcal{VERY\ IMPORTANT}$!!!!!

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

            $top := st.pop$

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

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

        $st.push(i)$

    $return\ re$

---

363. Max Sum of Rectangle No Larger Than k Google

Intuition & Algorithm

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

$$for(j = 0 \rightarrow n - 1):$$

$$col[j, 0] = mat[i, j]$$

$$for(i = 1 \rightarrow m - 1):$$

$$col[j, 0] \coloneqq col[j, i - 1] + mat[i, j]$$

$$re = 0$$

$$for(r_1 = 0 \rightarrow m - 1):$$

$$for(r_2 = r_1 \rightarrow m - 1):$$

$set = (\phi)^{TreeSet}, sum = 0$ ⋆ *set: store the presum in ascending order*

$$set.add(0)$$

$$int[\ ]\ A = [n]$$

⋆ compress multiple rows into one line

$$for(j = 0 \rightarrow n - 1):$$

$$A[j] = col[j, r_2] - col[j, r_1] + mat[r_1, j]$$

$$sum = sum + A[j]$$

⋆ *if there exists* $\sum_0^k A[k] \geq sum - k$, *then there exists* $\sum_{k+1}^j A[k] \leq k$

$$e = s.ceilKey(sum - k)$$

$$if(e \neq null): result = \max(result, sum - e)$$

$$set.add(sum)$$

$$return\ result$$

Follow Up: Max Sum Rectangle
Find a rectangular area whose sum equals s

$$result = 0$$

$$for(r_1 = 0 \rightarrow m - 1):$$

$$for(r_2 = r_1 \rightarrow m - 1):$$

$$for(j = 0 \rightarrow n - 1): col_j = a_{r_2, j} - a_{r_1, j} + matrix_{r_1, j}$$

$$result = \max\big(result, maxsubarray(col)\big)$$

$$return\ result$$

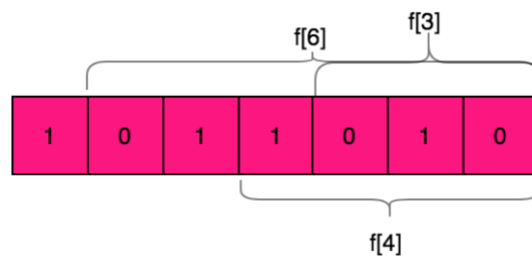## 600. Non-negative integers without consecutive ones Pocket Gems

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:
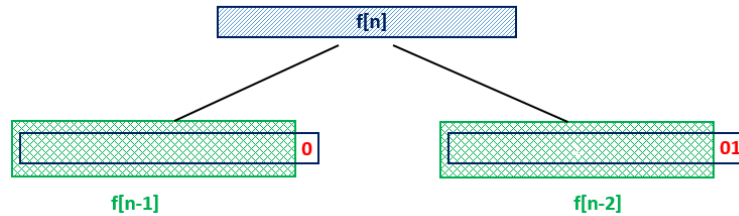
From the above figure, we can see that if we know the value of $f[n-1]$ and $f[n-2]$. In order to generate the required binary numbers with n bits, we can append a 0 to all the binary numbers contained in $f[n-1]$ without creating an invalid number. But, we can't append a 1 to all these numbers, since 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

$$f[n] := f[n-1] + f[n-2]$$

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

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

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

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

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

$while(i \geq 0):$

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

        $re := re + f[i]$

        $if(prevbit = 1): break$

        $prevbit = 1$

    $else: prevbit = 0$

    $i := i - 1$

$return \ re + checkIfExistsConsecutiveOnes(num)$

$int \ checkIfExistsConsecutiveOnes(num):$

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

    $i = le - 1$

    $while(i \geq 0):$

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

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

            $preb = 1$

        $else: preb = 0$

        $i := i - 1$

    $return \ 0$

152. Maximum Product Subarray LinkedIn

$result = A[0]$

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

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

    $temp = min_{here}$

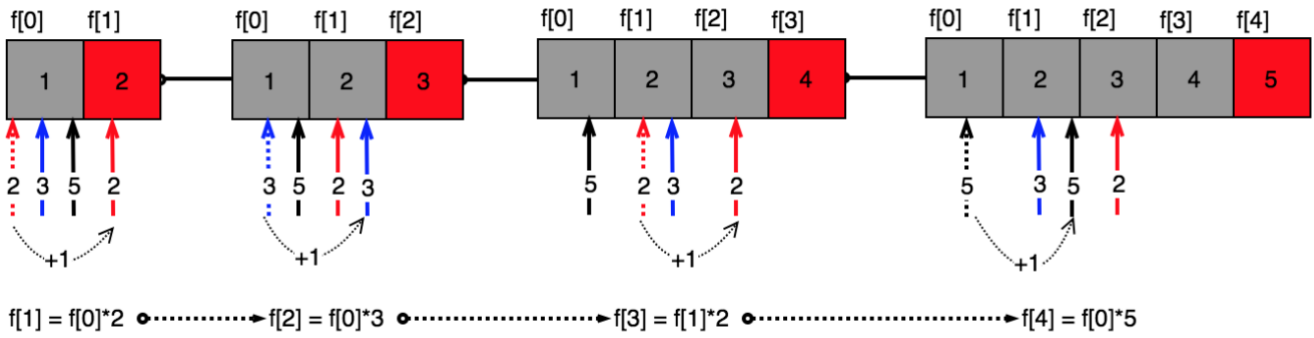 $min_{here} = \min(min_{here}, max_{here}, 1) \star A[i]$

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

313. Super Ugly Number

264. Ugly Number I

263. Ugly Number II

$$for(i = 0 \rightarrow len(primes) - 1):$$
$$\quad prime2index[primes[i]] \coloneqq 0$$
$$int[\,]\, f = [n+1], f[0] = 1$$
$$for(i = 1; i < n):$$
$$\quad minv = 2^{31} - 1, minp = -1$$
$$\quad for(p = 0 \rightarrow len(primes) - 1):$$
$$\qquad if\left(f\left[prime2index[primes[p]]\right] \star primes[p] > min\right):$$
$$\qquad\quad minv = f\left[prime2index[primes[p]]\right] \star primes[p], minp = p$$
$$\quad f[i] = minv$$
$$\quad prime2index[primes[minp]] \coloneqq prime2index[primes[minp]] + 1$$
$$\quad for(p = 0 \rightarrow len(primes) - 1):$$
$$\qquad if\left(minp \neq p \;\&\; f\left[prime2index[primes[p]]\right] \star p = minv\right):$$
$$\qquad\quad prime2index[primes[p]] \coloneqq prime2index[primes[p]] + 1$$

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

$lmin_i = \min(lmin_{i-1}, a[i])$:
$for(i = n - 1 \to 0)$:
    $j = set.lower(a_i)$ ⋆ *find the largest value that is smaller than a[i]*
    $rmin_i = j$ is null? a_i, j
    $set.add(a_i)$
$for(i = 1; i \leq n - 2;)$:
    $if(lmin_i < rmin_i < a_i)$ 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

$for(int \; x: nums):$

$\quad result = max\{result, x \oplus most \cdot different(x)\}$

$most \cdot different(TrieNode \; root, x):$

$\quad TrieNode \; p = o, x = 0$

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

$\quad\quad mask = 1 \ll i$

$\quad\quad b = (x \; \& \; mask) \gg i$

$\quad\quad if(p.next[1-b] \neq null):$

$\quad\quad\quad x = x * 2 + (1-b)$

$\quad\quad\quad p = p.next[1-b]$

$\quad\quad else:$

$\quad\quad\quad x = x * 2 + b$

$\quad\quad\quad p = p.next[b]$

$return \; x$

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

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

$\quad for(j = 0 \rightarrow A[0].length - 1):$

$\quad\quad if(\mathcal{R}.next[A[i,j] - a] \neq nil):$

$\quad\quad\quad used[i,j] \coloneqq True$

$\quad\quad\quad s \coloneqq ""$

$\quad\quad\quad dfs(A, i, j, \mathcal{R}.next[A[i,j] - a], used, s + A[i,j])$

$\quad\quad\quad used[i,j] \coloneqq False$

$void \; \mathcal{DFS}(A, i, j, p, used, s):$

$\quad if(p.isword):$

$\quad\quad re.add(s)$

$\quad\quad \star DO \; NOT \; return \; here$

$\quad for((nx, ny) \in (i,j).next):$

$\quad\quad index \coloneqq A[n_x, n_y] - a$

$\quad\quad if(p.next[index] \neq nil \; \& \; used[n_x \star n + n_y] = nil):$

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

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⟨Long, Integer⟩ smap = null
    TreeMap⟨Long, Integer⟩ mp
    for(int x: nums):
        sum ← sum + x
        sortedmp ← mp.subMap(sum − upper, sum − lower, true)
        for(int e: sortedmp.values): result := result + e
        mp[sum] := 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 ≤ 1): return head
```

$cnt = 0, p = head$

$for(; p \neq nil \ \& \ cnt < k; \ cnt := cnt + 1): p := p.next$

★ 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

$double \ myPow(double \ x, int \ n):$

    $double \ v := x, re := 1.0, M := Double.MaxValue$

    $int \ sign := n < 0 \rightarrow -1: 1:$

    $long \ N := (long)n$

    $while(N > 0):$

        $if\big((N \ \& \ 1) = 1\big): re := re \star v$

        $N \gg= 1$

        $v \mathrel{*}= v$

    $return \ sign = -1 \rightarrow \frac{1.0}{re}: re$

56. Merge Intervals Google Facebook Microsoft Bloomberg LinkedIn Twitter Yelp

Given a collection of intervals, merge all overlapping intervals.

$\mathcal{N} := len(intervals)$

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

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

$Interval\ prev := intervals[0]$

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

$\quad current := intervals[i]$

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

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

$re.add(prev)$

$return\ re$

Follow Up: Merge Two Sorted Interval List /
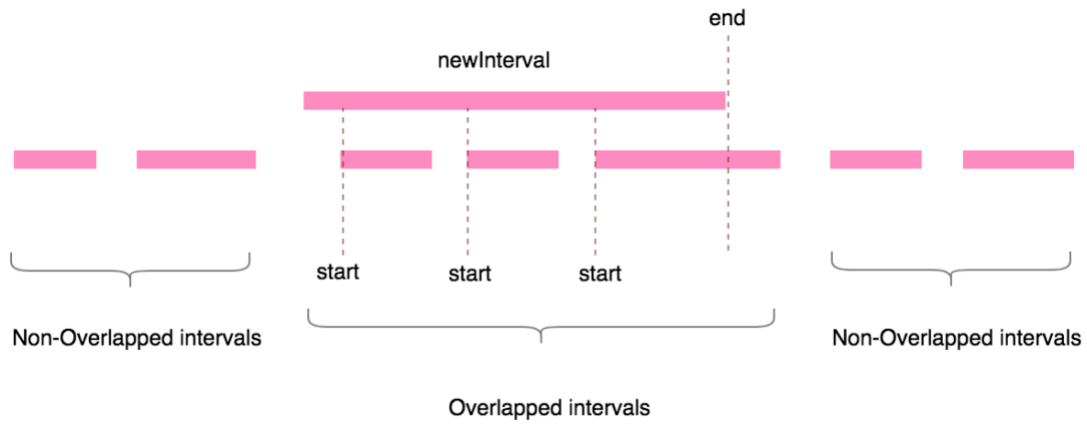**Collect All Intersection of Two Sorted Interval List**

Intuition & Algorithm
Like Merge Two Sorted Arrays

153. Find Minimum in Rotated Sorted Array Facebook

$l = 0, r = n - 1$

$while(l < r):$

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

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

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

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

$return\ a_l$

57. Insert Interval Google LinkedIn Facebook

Intuition & Algorithm

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

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

$\quad n \coloneqq len(A)$

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

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

$\quad index \coloneqq 0$

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

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

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

$\quad\quad index \coloneqq index + 1$

$\quad re.add(new)$

$\quad while(index < n): re.add(A[index++])$

$\quad return\ re$

154. Find Minimum in Rotated Sorted Array II

$l = 0, r = n - 1$

$while(l < r):$

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

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

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

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

$return\ a_l$

461. Hamming Distance Facebook

```
int hammingDistance(x, y):
    re ≔ 0
    for(d = 31 → 0)
        mask ≔ (1 ≪ d)
        dx, dy ≔ ((x & mask) ≫ d), ((y & mask) ≫ d)
        if(dx ≠ dy): re ≔ 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 ≔ 0
    bits ≔ [32]
    for(d = 31 → 0):
        mask ≔ (1 ≪ d)
        for(i = 0 → len(A) − 1):
            da_i ≔ ((A[i] & mask) ≫ d)
            bits[d] ≔ bits[d] + da_i
        re ≔ re + bits[da_i] ⋆ (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.

$l = 0, r = n - 1$

$$while(l \leq r):$$
$$\quad if(l \ knows \ r): l = l + 1 \ (because \ celebrity \ knows \ nobody)$$
$$\quad elif(l \ doen't \ know \ r): r = r - 1 (because \ celebrity \ should \ be \ known \ by \ everyone)$$
$$check \ if \ l \ is \ the \ celebrity \ again$$

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.

$$int \ leastBricks(List[List[int]] \ wall):$$
$$\quad most := 0$$
$$\quad map := \{int \Rightarrow int\}$$
$$\quad for(List[int] \ \ell ine: bricks):$$
$$\quad\quad pos := 0$$
$$\quad\quad for(i = 0 \rightarrow len(\ell ine) - 1):$$
$$\quad\quad\quad pos := pos + \ell ine[i]$$
$$\quad\quad\quad map[pos] := map[pos] + 1$$
$$\quad\quad\quad most := \max(most, map[pos])$$
$$\quad return \ len(wall) - most$$

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[p₂++] = 2, A[p₁++] = 1, A[p₀++] = 0
    elif(x = 1): A[p₂++] = 2, A[p₁++] = 1
    else: A[p₂++] = 2
```

$for(int\ x: A)$:

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

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

$\quad else: A[p_2++] = 2$

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,

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

$while(mid \leq r)$

$\quad if(A[mid] = 0): swap(A[mid++], A[l++])$

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

$\quad else: swap(A[r--], A[mid])$

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

$$void\ moveZeros(int[\ ]\ \mathcal{A}):$$
$$\quad int\ wall := 0:$$
$$\quad for(i = 0 \rightarrow len(\mathcal{A}) - 1):$$
$$\quad\quad if(\mathcal{A}[i] \neq 0): swap(\mathcal{A}, i, wall), wall := wall + 1$$

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.

$$xor = nums[0]$$
$$for(i = 1 \rightarrow \mathcal{A}.length - 1): xor = xor \oplus \mathcal{A}[i]$$
$$bit = xor \oplus \sim(xor - 1)$$
$$rs_0 = 0, rs_1 = 0$$
$$for(int\ x: \mathcal{A}):$$
$$\quad if\big((x\&bit) > 0\big): rs_0 = rs_0 \oplus x$$
$$\quad else: rs_1 = rs_1 \oplus x$$
$$return\ (rs_0, rs_1)$$

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 → 31):
    mask = 1 ≪ i
    d = (n & mask) ≫ 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 · bound(target, A):
    l = 0, r = len(A) − 1, ub = −1
    while(l ≤ 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 <mark>VMware</mark>

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

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

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

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

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

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

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

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

$$d \coloneqq mod(d, 3)$$

$$result \coloneqq result \star 2 + d$$

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.

$int\ minSubArray(S, A)$:

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

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

  $cur := cur + A[r]$

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

   $if(cur - A[l] \geq S)$: $cur := cur - A[l]$

   $else$: $break$

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

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

Follow Up: Integers are not all positive.

Intuition & Algorithm

Hash Map

413. Arithmetic Slices

$i = 0, counter = 0$

$while(i < n - 1)$:

 $j = i + 1$

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

 $le = j - i + 1$

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

 $i = j$

$return\ counter$

---

4. Median of Two Sorted Arrays

Google Amazon Microsoft Apple Zenefits Yahoo Adobe Dropbox
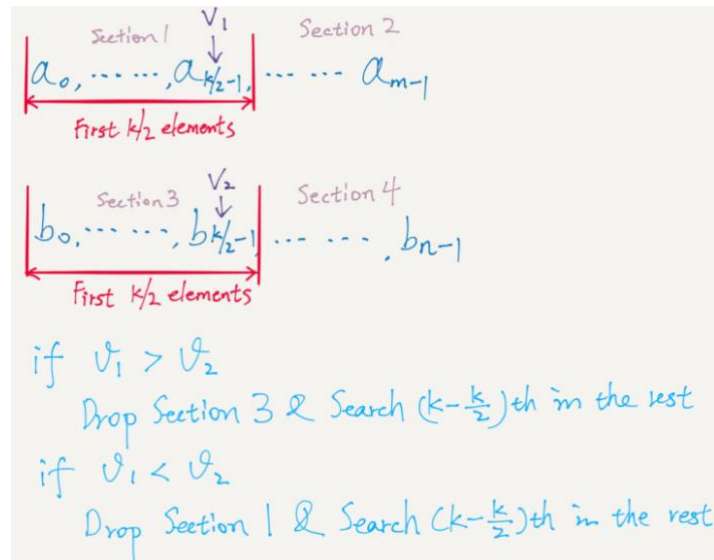
Intuition & Algorithm

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 kth element of another*

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

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

   $\star$ *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

case #1

case #2

case #3

case #4
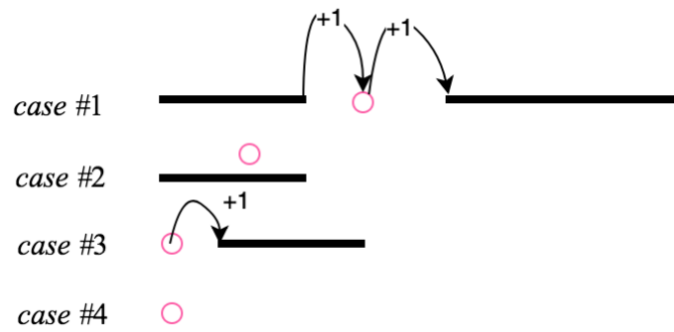
$map[start] \Rightarrow [start, end]$

$addNum(int\ val)$:

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

    $l := map.lowerKey(val)$

    $r := map.higherKey(val)$

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

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

        $map[r] = nil\ \star\ remove\ this\ interval$

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

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

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

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

        $map[r] = nil$

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

348. Design Tic-Tac-Toe Google Microsoft

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

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

$boolean\ find(arr, target):$

 $index \leftarrow findRotatedPosition(arr)$

 $if\ \big(bin \cdot search(arr, 0, index - 1)\ \&\ bin \cdot search(arr, index, arr. length)\big):$

  $return\ true$

 $else: return\ false$

$int\ findRotatedPosition(A)$

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

 $while\ (l < r):$

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

  $if\ (A[mid] < A[r]): r := mid$

  $else: l := mid + 1$

 $return\ l$

34. Search for a Range

Search for the lower & upper boundary of given value

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

 $lb \leftarrow lower \cdot boudnary(A, target)$

 $rb \leftarrow upper \cdot boudnary(A, target)$

 $return\ new\ int[]\ \{lb, rb\}$

$int\ lower \cdot boudnary(A, target)$

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

 $while\ (l < r):$

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

  $if\ (A[mid] = target): lb = mid, r := r - 1$

  $elif\ (A[mid] < target): l := mid + 1$

  $else: r = mid - 1$

35. Search insert position

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

$while(l < r):$

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

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

    $else: l = mid + 1$

$return\ l$

240. Search a 2D Matrix II Google Apple Amazon

Intuition & Algorithm

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

Time Cost: $O(m + n)$

$r = 0, c = matrix[0].length - 1$

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

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

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

    $else: r := r + 1$

$return\ false$

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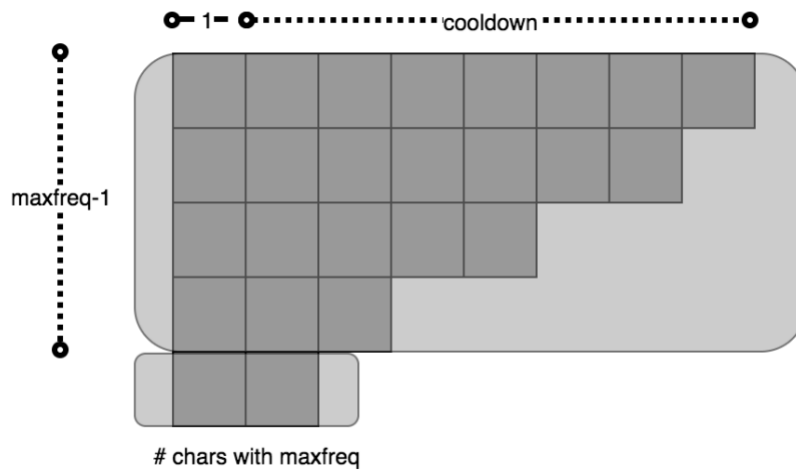
$$for\ example, (A_3, B_3, C_2, cooldown = 2) \rightarrow \begin{bmatrix} A & B & C \\ A & B & C \\ A & B & \end{bmatrix}$$

Algorithm

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

767. Reorganize String Uber Google

Algorithm #1
priority queue

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

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

$$cell \leftarrow array_{2d}(unique\ char \times max \cdot freq, default = '\#')$$
$$for(freq = len(str) \rightarrow 1):$$
$$\quad if(map[freq] \neq nil):$$
$$\quad\quad list\langle char\rangle\ ls \leftarrow map[freq]$$
$$\quad\quad for(char\ ch\ in\ ls):$$
$$\quad\quad\quad for(i = 0 \rightarrow freq): cell[rowid].add(ch)$$

66

$$rowid += 1$$
$$i = 0, j = 0$$
$$for(; j < max \cdot freq;):$$
$$\quad for(; i < rowid;):$$
$$\quad\quad if(cell_{i,j} ==' \#'): break$$
$$\quad\quad print(cell_{i,j})$$

3. Longest Substring Without Repeating Characters

$$count = \{\phi\}$$
$$l = 0$$
$$for(r = 0; r < s.length;)$$
$$\quad count[s[r]] \coloneqq count[s[r]] + 1$$
$$\quad while(l \leq r \,\&\, count[s[r]] > 1):$$
$$\quad\quad counts[s[l--]] -= 1$$
$$\quad result = max(result, r - l + 1):$$
$$return\ result$$

389. Find the difference <mark>Google</mark>
Algorithm

$$count = [256]: int$$
$$for(i = 0; i < s.length;): count[s[i]] \coloneqq count[s[i]] + 1$$
$$for(i = 0; i < s.length;): count[s[i]] \coloneqq count[s[i]] - 1$$
$$for(c = a \rightarrow z): if(count[c] \neq 0): result = c$$

409. Longest Palindrome <mark>Google</mark>

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 <mark>Bloomberg</mark>

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

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

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

15. 3Sum & 18. 4Sum

$Arrays.sort(nums)$

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

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

$\quad while(l < r):$

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

$\quad\quad\quad l := l + 1, r := r - 1$

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

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

$\quad\quad elif(a_i + a_l + a_r > target): r := r - 1$

$\quad\quad else: l := l + 1$

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

$wall = 1$

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

$\quad if(i \geq 1 \,\&\, A[i] \neq A[i - 1]):$

$\quad\quad A[wall++] = A[i]$

$return\ wall$

27. Remove Element

$wall = 0$

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

$\quad if(A[i] \neq val): A[wall++] := A[i]$

$return\ wall$

392. Is Subsequence Uber

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

$$if(s[p_s] = t[p_t]): p_t += 1$$

$$p_s += 1$$

$$return \; p_t == len(t)$$

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

$$for(String \; t : strList):$$

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

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

$$\quad \quad i \leftarrow i + 1$$

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

---

204. Count Primes

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

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

$$\quad if(is \cdot prime[i]) \; result += 1$$

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

$$return \; result$$

---

451. Sort Characters by Frequency <mark>Bloomberg</mark>

Solution I: Bucket Sort

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

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

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

$$for(char \; c : str):$$

$$\quad counter[c] += 1$$

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

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

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

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

---

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 <u>it is possible to do word count with hash-map, but not possible to allocate such number of buckets for bucket sort</u>. So, an optimized solution is Quick-Select, it takes $O(n)$ time and $O(k)$ **space**, where n is the number of words in text.

$$for(word\ w: text): map[w] = map[w] + 1$$
$$freq_{array,1d} = map.values()$$
$$k^{th} \cdot freq = quick \cdot select(freq, 0, len(freq) - 1, len(freq) - k)$$
$$for(Map.Entry\langle word, freq\rangle\ entry: map.entrySet()):$$
$$\quad if(entry.getValue() \geq k^{th} \cdot freq):$$
$$\quad\quad result.add(entry.getKey())$$
$$\quad if(result.size() = k): break;$$
$$return\ result$$

76. Minimum Window Substring &
567. Permutation in String &
438. Find All Anagrams in a String Uber

$$minimum \cdot window \cdot substring(s, t):$$
$$\quad for(i = 0 \rightarrow len(t) - 1):$$
$$\quad\quad need \cdot find[t[i]] := need \cdot find[t[i]] + 1$$
$$\quad l = 0, e = 0$$
$$\quad for(r = 0; r < s.length;):$$
$$\quad\quad has \cdot found[s[r]] := has \cdot found[s[r]] + 1;$$
$$\quad\quad if(has \cdot found[s[r]] \leq need \cdot find[s[r]]): e := e + 1$$
$$\quad\quad if(e = len(target)):$$
$$\quad\quad\quad while(need \cdot find[s[l]] = 0\ ||\ has \cdot found[s[l]] > need \cdot find[s[l]]):$$
$$\quad\quad\quad\quad if(has \cdot found[s[l]] > need \cdot find[s[l]]):$$
$$\quad\quad\quad\quad\quad has \cdot found[s[l]] := has \cdot found[s[l]] - 1$$
$$\quad\quad\quad\quad l := l + 1$$
$$\quad return\ s_{l,r}$$

138. Copy List with Random Pointer Amazon

$$for(Node\ nd: list):$$
$$\quad nd \cdot copy \leftarrow make \cdot copy(nd)$$
$$\quad map(nd) \rightarrow nd \cdot copy$$
$$for(Node\ nd: list):$$
$$\quad map[nd].next = map[nd.next]$$
$$\quad map[nd].randomNext = map[nd.randomNext]$$

133. Clone Graph Google Facebook Uber Pocket Gems

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

$$for(g: graph.nodes):$$
$$\quad list\langle node \rangle\ adjs \leftarrow g.adjacents$$
$$\quad for(node\ nd: adjs):$$
$$\quad\quad map[g].adjacentlist.add(map[nd])$$

31. Next Permutation Facebook

Generate next slightly greater number with same digits

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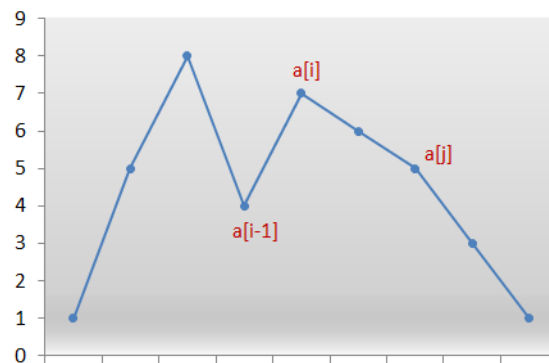
Find first ℓ s $\mathcal{A}[\ell] < \mathcal{A}[\ell]$ t. from rightmost, then find first r in range of $[\ell + 1, r - 1]$ s.t $\mathcal{A}[\ell] < \mathcal{A}[r]$ from right-most. Next, swap $(\mathcal{A}[\ell], \mathcal{A}[r])$. Finally, sort $\mathcal{A}[l + 1: n - 1]$

Next Palindromic Number

Consider three conditions:

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

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

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

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

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

$wall = 1, count := 0$
$for(i = 1 \rightarrow len(A) - 1):$
  $count := (A[i] = A[i - 1]) \rightarrow count + 1 : 0$
  $if(count < 2):$
    $A[wall++] := A[i]$
$return\ wall$

442. Find all Duplicates in an Array Pocket Gems

Intuition & Algorithm

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

$re := [\phi], n := len(A)$
$for(i = 0 \rightarrow n - 1):$
  $int\ index := |A[i]| - 1$
  $if(index < n): re.add(index + 1)$
  $else: A[index] \star= -1$
$return\ re$

41. First Missing Positive

448. Find All numbers disappeared in an array

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

$$for(i = 0; i < len(arr) - 1):$$
$$\quad if(arr[i] > 0): arr[le + +] = arr[i]$$
$$for(i = 0 \rightarrow le - 1):$$
$$\quad idx = |arr_i| - 1$$
$$\quad if(idx < le \ \& \ arr[idx] > 0): arr[idx] \mathrel{:=} arr[idx] \star -1$$
$$for(i = 0 \rightarrow le - 1):$$
$$\quad if(arr[i] > 0): return \ (i + 1)$$

Common Chars in n strings

$$first = 0$$
$$for(char \ c: s[0]): first \leftarrow first \ | \ (1 \ll (c - a))$$
$$for(i = 1 \rightarrow n - 1):$$
$$\quad second = 0$$
$$\quad for(char \ c: s[i]): second \mathrel{:=} second \ | \ (1 \ll (c - a))$$
$$\quad first = first \ \& \ second$$
$$for(i = 0 \rightarrow 26):$$

$$\quad if\left((first \ \& \ (1 \ll i)) \gg i == 1\right): re \mathrel{:=} re + (char)(i + a)$$

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 $encode = encode \ | \ (1 \ll (str[i] - 'a')), \forall i \in [0, le - 1]$, 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 $O(m \star \log(n) + n \star \log(m))$

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

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

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

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

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

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

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

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

 $while(top \le bottom):$

  $mid \coloneqq \frac{top + bottom}{2}$

  $s \coloneqq 0$

  $for(j = 0 \to len(image[mid]) - 1): s \coloneqq s + image[mid, j]$

  $if(s \ge 1):$

   $re \coloneqq mid$

   $if(searchTop): bottom \coloneqq mid - 1$

   $else: top \coloneqq mid + 1$

  $else:$

   $if(searchTop): top \coloneqq mid + 1$

   $else: bottom \coloneqq mid - 1$

 $return\ re$

$int\ searchHorizontal(int[\ ][\ ]\ image, int\ left, int\ right, bool\ searchLeft):$

 $re \coloneqq searchLeft = True \to right : left$

$$while(left \leq right):$$
$$mid := \frac{left + right}{2}$$
$$s := 0$$
$$for(i = 0 \rightarrow len(image) - 1): s := s + image[i, mid]$$
$$if(s \geq 1):$$
$$re := mid$$
$$if(search\mathcal{L}eft): right := mid - 1$$
$$else: left := mid + 1$$
$$else:$$
$$if(search\mathcal{L}eft): left := mid + 1$$
$$else: right := mid - 1$$
$$return\ re$$

235. LCA of BST & BT

236. LCA of BT

$$lca \cdot bst(TreeNode\ o, int\ lb, int\ rb):$$
$$if(o = nil): return\ null$$
$$if(lb \leq o.val \leq rb): return\ o.val$$
$$elif(lb > o.val): return\ lca \cdot bst(o.right, lb, rb)$$
$$else: return\ lca \cdot bst(o.left, lb, rb);$$

$$lca \cdot bt(TreeNode\ o, TreeNode\ p, TreeNode\ q):$$
$$if(o\ is\ null): return\ null$$
$$if(o = p): return\ p$$
$$if(o = q): return\ q$$
$$lo \leftarrow lca \cdot bt(o, p, q)$$
$$ro \leftarrow lca \cdot bt(o, p, q)$$
$$if(lo \neq nil\ \&\ ro \neq nil): return\ o;$$
$$if(lo = nil\ \&\ ro \neq nil): return\ ro$$
$$if(lo \neq nil\ \&\ ro = nil): return\ lo$$
$$return\ null$$

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/

$stack(type = TreeNode)$

$BSTIterator(TreeNode\ root):$

$$node = root$$

$$while(node \neq null):$$

$$\quad stack.push(node)$$

$$\quad node = node.left$$

$$boolean\ hasNext():$$

$$\quad return\ !\ stack.isEmpty()$$

$$int\ next():$$

$$\quad node = stack.pop()$$

$$\quad if(node.right \neq null):$$

$$\quad\quad node = node.right$$

$$\quad\quad while(node \neq null):$$

$$\quad\quad\quad stack.push(node)$$

$$\quad\quad\quad node = node.left$$

$$\quad return\ node.val$$

98. Validate Binary Search Tree Facebook Microsoft Amazon Bloomberg

$$min = -2^{31}, max = 2^{31} - 1$$

$$check(TreeNode\ o, int\ min, int\ max):$$

$$\quad if(o = nil): return\ true$$

$$\quad if(o.val \in [min, max]\ \&\ check(o.l, min, o.val)\ \&\ check(o.r, o.val, max))$$

$$\quad\quad return\ true$$

$$\quad return\ false$$

99. Recover Binary Search Tree

Two nodes are mistakenly swapped in BST, asked to find them and swap back

$$void\ recoverTree(TreeNode\ R):$$

$$\quad prev \coloneqq nil, 1^{st} = nil, 2^{nd} = nil$$

$$\quad stack \coloneqq \{\phi\}$$

$$\quad TreeNode\ p \coloneqq R$$

$$\quad while(p \neq nil): stack.push(p), p \coloneqq p.left$$

$$\quad while(stack.size > 0):$$

$$\quad\quad curr \coloneqq stack.pop$$

$$\quad\quad if(prev \neq nil\ \&\ prev.val \geq curr.val):$$

$$if(1^{st} \neq nil): 1^{st} = prev$$
$$2^{nd} = curr$$
$$prev := curr$$
$$if(curr.right \neq nil):$$
$$r := curr.right$$
$$while(r \neq nil): stack.push(r), r := r.left$$
$$swap(1^{st}, 2^{nd})$$

285. In-order Successor in BST Facebook Microsoft Pocket Gems

$$TreeNode\ suc := nil$$
$$while(root \neq nil):$$
$$if(p.val \geq root.val): root := root.right$$
$$else: suc = root, root := root.left$$
$$return\ suc$$

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

$$s_1 \coloneqq \{\phi\}, s_2 \coloneqq \{\phi\}$$

$$s_1.push(root)$$

$$while(s_1.size > 0):$$

$$\quad Node\ node \coloneqq s_1.pop$$

$$\quad s_2.push(node)$$

$$\quad if(node.left \neq nil): s_1.push(node.left)$$

$$\quad if(node.right \neq nil): s_1.push(node.right)$$

$$Postorder \coloneqq s_2.top \rightarrow s_2.bottom$$

199. Binary Tree Right Side View NewsOnChat

$$rightView = \{\phi\}$$

$$Q = \{root\}$$

$$while(Q\ isn't\ empty):$$

$$\quad n = Q.size$$

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

$$\quad\quad node = Q.poll()$$

$$\quad\quad if(i = n - 1): rightView.offer(node.val)$$

$$\quad\quad if(node.left \neq null): Q.offer(node.left)$$

$$\quad\quad if(node.right \neq null): Q.offer(node.right)$$

$$return\ rightView$$

226. Invert Binary Tree

Solution: reverse left-sub tree & right-sub tree first, then swap left & right pointer.

$$invert(TreeNode\ o):$$

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

$$\quad TreeNode\ lc \leftarrow invert(o.left)$$

$$\quad TreeNode\ rc \leftarrow invert(o.right)$$

$$\quad temp \leftarrow o.left$$

$$\quad o.left \leftarrow o.right$$

$$\quad o.right \leftarrow temp$$

$$\quad return\ o$$

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.

$void\ serialize(TreeNode\ root, StringBuffer\ sb)$

    $if(root\ is\ nil): sb.append(\#), return;$

    $sb.append(root.val + ", ")$

    $serialize(root.left, sb)$

    $serialize(root.right, sb)$

$Treeode\ de \cdot serialize(list\langle str\rangle\ nodes)$

    $if(nodes.empty\ ||\ nodes.peek ==' \#'):$

        $if(nodes.not \cdot empty): nodes.pollFirst$

        $return\ null$

    $TreeNode\ root \leftarrow new\ TreeNode(int(nodes.pollFirst))$

    $root.left \leftarrow de \cdot serialize(nodes)$

    $root.right \leftarrow de \cdot serialize(nodes)$

$return\ root$

Follow Up: Succinct serialization & de-serialization <mark>Google</mark>

Use two lists, one is called structure, another is called data, both are stored in pre-order.

$void\ serialize(root, structure: list, data: list)$

    $if(root\ is\ nil):$

        $structure.add(0), return$

    $structure.add(1)$

    $data.add(root.val)$

    $serialize(root.left, structure, data)$

    $serialize(root.right, structure, data)$

$Treeode\ de \cdot serialize(structure, data):$

    $if(nodes.empty): return\ nil$

    $bool\ b = structure.peekFirst$

    $if(b == 0): structure.pollFirst$

    $else:$

        $TreeNode\ root \leftarrow new\ TreeNode(int(data.pollFirst))$

        $root.left \leftarrow de \cdot serialize(structure, data)$

        $root.right \leftarrow de \cdot serialize(structure, data)$

        $return\ root$

    $return\ null$

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

$TreeNode\ deleteNode(TreeNode\ o, key):$

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

    $o.left = deleteNode(o.left, key)$

$$o.right = deleteNode(o.right, key)$$

$$if(o.val \neq key): return\ o$$

$$else:$$

$$\quad p = o.right;$$

$$\quad if(p\ is\ null): return\ o.left$$

$$\quad while(p.left\ is\ not\ null): p = p.left$$

$$\quad swap(p, o)$$

$$\quad o.right = deleteNode(o.right, key)$$

$$\quad return\ o$$

104. Maximum Depth of Binary Tree

Solution: $depth(o) = max\ \{depth(o.left), depth(o.right)\} + 1$

110. Balanced BT Bloomberg

$$depth(TreeNode\ o):$$

$$\quad if(o\ is\ null): return\ 0$$

$$\quad lheight \coloneqq depth(o.left)$$

$$\quad rheight \coloneqq depth(o.right)$$

$$\quad if(lheight = -1\ or\ rheight = -1\ or\ abs(lheight - rheight) > 1):$$

$$\quad\quad return\ -1$$

$$\quad return\ \max(lheight, rheight) + 1$$

$$balanced = \ depth(o) = -1$$

Interview Q. Preorder to BST

$$index = 0, min = -2^{31}, max = 2^{31} - 1$$

$$TreeNode\ pre2BST(preorder_{(type=array,1d)}, min, max):$$

$$\quad if(index > preorder.length): return\ null$$

$$\quad if(preorder[index] \in [min, max]):$$

$$\quad\quad root = new\ TreeNode(preorder[index + +])$$

$$\quad\quad root.left = pre2BST(preorder, min, root.val)$$

$$\quad\quad root.right = pre2BST(preorder, root.val, max)$$

$$return\ root$$

323. Number of Connected Components in an Undirected Graph

Solution: union-find

$$CC = N(vertices)$$
$$for(edge\ e: edges):$$
$$\quad o_1 = find(e.from)$$
$$\quad o_2 = find(e.to)$$
$$\quad if(o_1 \neq o_2):$$
$$\quad\quad union(o_1, o_2)$$
$$\quad\quad CC = CC - 1$$

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:

$$\mathcal{D}(o) = (h[o.left] + h[o.right]), h[nil] := 0$$
$$re := \max\big(\mathcal{D}(o), \mathcal{D}(o.left), \mathcal{D}(o.right)\big)$$

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

$$height: map(Node, height)$$
$$int\ longest \cdot path(Node\ root):$$
$$\quad if(root == null): return\ 0$$
$$\quad childNum \leftarrow root.childs.size()$$
$$\quad result = 0$$
$$\quad for(i = 0 \rightarrow childNum - 1): \star\ find\ LP\ in\ root's\ subtrees$$
$$\quad\quad result = \max(result, longest \cdot path(root.childs[i]))$$
$$\quad mx_1 = null, mx_2 = null$$
$$\quad for(i = 0 \rightarrow childNum - 1):$$
$$\quad\quad h \leftarrow height[root.childs[i]]$$
$$\quad\quad if(mx_1 = null\ ||\ h > mx_1):$$
$$\quad\quad\quad mx_2 = mx_1, mx_1 = h$$

$$elif\ (mx_2 = null\ ||\ h > mx_2):$$

$$mx_2 = h$$

$$mx_1 = mx_1 = nil \rightarrow 0: mx_1$$

$$mx_2 = mx_2 = nil \rightarrow 0: mx_2$$

$$re = \max(re, mx_1 + mx_2 + 1)$$

$return\ re$

$int\ depth(Node\ root):\star\ height[root] = \max\big(height[child[i]]\big) + 1, \forall i \in [0, size(root.childs)]$

    $if\ (root = null): return\ 0$

    $childNum \leftarrow root.childs.size()$

    $maxh = 0$

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

        $h = depth(root.childs[i])$

        $maxh = \max(maxh, h)$

    $height[root] = maxh + 1$

    $return\ maxh + 1$

$main():$

    $Node\ root = buildTree()$

    $depth(root)$

    $result = longest \cdot path(root)$

549. Binary Tree Longest Consecutive Sequence II Google
Follow Up: N-ary Tree Longest Consecutive Sequence

$incr: map(Node \Rightarrow length\ of\ longest\ increasing\ consecutive\ sequence\ end\ up\ with\ this\ node)$

$decr: map(Node \Rightarrow length\ of\ longest\ decreasing\ consecutive\ sequence\ end\ up\ with\ this\ node)$

$int\ longest \cdot consecutive \cdot sequence(Node\ root):$

    $if\ (root == null): return\ 0$

    $childNum \leftarrow root.childs.size$

    $result = 0$

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

        $result = \max(result, longest \cdot consecutive \cdot sequence(root.childs[i]))$

    $maxh_{incr} = null, maxh_{decr} = null$

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

$\quad if(root.child[i].val + 1 = root.val): h_{incr} \coloneqq incr[root.childs[i]]$

$\quad if(root.child[i].val - 1 = root.val): h_{decr} \coloneqq decr[root.childs[i]]$

$\quad if(maxh_{incr} = null \mid\mid h_{incr} > maxh_{incr}): maxh_{incr} = h_{incr}$

$\quad if(maxh_{decr} = null \mid\mid h_{decr} > maxh_{decr}): maxh_{decr} = h_{decr}$

$maxh_{incr} = (maxh_{incr} = null)? 1: maxh_{incr} + 1$

$maxh_{decr} = (maxh_{decr} = null)? 0: maxh_{decr} + 1$

$result = \max(result, maxh_{incr} + maxh_{decr} - 1)$

$return\ result$

$int\ getIncrDepth(Node\ root):$

$\quad if(root == null): return\ 0$

$\quad childNum \leftarrow root.childs.size$

$\quad maxh_{incr} = 0$

$\quad for(i = 0 \rightarrow childNum - 1):$

$\quad\quad h = getIncrDepth(root.childs[i])$

$\quad\quad if(root.child[i].val + 1 == root.val): maxh_{incr} = \max(maxh_{incr}, h)$

$\quad incr[root] = maxh_{incr} + 1$

$\quad return\ maxh_{incr} + 1$

$int\ getDecrDepth(Node\ root):$

$\quad if(root == null): return\ 0$

$\quad childNum \leftarrow root.childs.size$

$\quad maxh_{decr} = 0$

$\quad for(i = 0 \rightarrow childNum - 1):$

$\quad\quad h = getDecrDepth(root.childs[i])$

$\quad\quad if(root.child[i].val + 1 == root.val): maxh_{decr} \leftarrow \max(maxh_{decr}, h)$

$\quad decr[root] = maxh_{decr} + 1$

$\quad return\ maxh_{decr} + 1$

Largest Complete Tree **ForUsAll**

the height of complete tree is: $h = \mathbf{min}\big(height(o.l), height(o.r)\big) + 1$, 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

$n \coloneqq 0, p \coloneqq head$

$while(p \neq nil): n := n + 1, p := p.next$

$list2bst(int\ n):$

    $if(n \leq 0\ or\ head = nil): return\ nil$

    $l = list2bst\left(\frac{n}{2}\right) \star$ *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

```
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
```

$$elif(o.right \neq nil): o = o.right$$

$$else: o = find \cdot nephew(o)$$

$$Node\ find \cdot nephew(p: Node):$$

$$q = p.nextR$$

$$while(q \neq nil):$$

$$if(q.left \neq nil): return\ q.left$$

$$if(q.right \neq nil): return\ q.right$$

$$q = q.nextR$$

$$return\ nil$$

Queue & Stack & Greedy& Heap

155. Minimum Stack

Follow Up: Maximum & Minimum Stack <mark>ForUsAll</mark>

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:

$List\ flatten(List\langle NestedInteger\rangle\ list):$

$\quad List\ result \leftarrow \{\phi\}$

$\quad for(NestedInteger\ each: list): stack.push(each)$

$\quad while(stack\ isn't\ empty):$

$\quad\quad NestedInteger\ top \leftarrow stack.pop()$

$\quad\quad if(top\ is\ a\ number):$

$\quad\quad\quad result.addFirst(top)$

$\quad\quad else:$

$\quad\quad\quad for(NestedInteger\ ne: top): stack.push(ne)$

$return\ result$

225. Implement Stack using Queues

solution:

$void\ push(int\ x):$

$\quad queue.offer(x)$

$\quad for(i = 0; i < queue.size - 1;): queue.offer(queue.poll())$

321. Create Maximum Number Google

$int[\ ]\ maxNumber(int[\ ]\ nums1, int[\ ]\ nums2, int\ k):$

$\quad m := len(nums1), n := len(nums1), re = [k]$

$\quad for(len = 0 \rightarrow k):$

$\quad\quad if(len < m\ \&\ k - len < n):$

$\quad\quad\quad int[\ ]\ A := maxNumberOfKdigits(nums1, len)$

$\quad\quad\quad int[\ ]\ B := maxNumberOfKdigits(nums2, k - len)$

$\quad\quad\quad re := \max(re, merge(A, B))$

$\quad return\ re$

$int[\ ]\ maxNumberOfKdigits(A, len):$

$re = [len], Stack\ stack$

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

　　$remains \coloneqq len(A) - i - 1 \star [i + 1, len(A) - 1]$

　　$while(A[i] > A[stack.peek] \& remains + stack.size \geq k): stack.pop$

　　$if(stack.size < k)\ stack.push(i)$

$e \coloneqq len - 1$

$while(\sim stack.empty): re[e\text{--}] \coloneqq A[stack.pop]$

$return\ re$

$int[\ ]\ merge(A, B):$

　$i = 0, j = 0, re = [len(A) + len(B)]$

　$while(i < len(A)\ \& j < len(B)):$

　　$if(compare(A, i, B, j)): re[e\text{++}] \coloneqq A[i\text{++}]$

　　$else: re[e + +] = B[j + +]$

　$while(i < len(A)): re[e + +] = A[i + +]$

　$while(j < len(B)): re[e + +] = B[j + +]$

　$return\ re$

$int\ compare(A, i, B, j):$

　$while(i < len(A)\ \& j < len(B)\ \& A[i] = B[j]): i \coloneqq i + 1, j \coloneqq j + 1$

　$if(i < len(A)\ \& j < len(B)): return\ A[i] - B[j]$

　$elif(i < len(A)\ \& j = len(B)): return\ 1$

　$else: return -1$

$int\ max(int[\ ]\ A, int[\ ]\ B):$

　$for(i = 0 \rightarrow len(A)):$

　　$if(A[i] > B[j]): return\ A$

　　$else: return\ B$

　$return\ A$

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.

$remove \cdot duplicates(s):$

    $distincts \coloneqq 0$

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

        $remains[s[i]] \coloneqq remains[s[i]] + 1$

        $if(remain[s[i]] = 1): distincts \coloneqq distincts + 1$

    $stack[int]\ st: ascending\ order$

    $used: hashset$

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

        $counts[strs[i]] \coloneqq counts[strs[i]] - 1$

        $\star\ if\ current\ char\ has\ not\ shown\ up\ in\ the\ stack\ and\ the\ remainings > 0$

        $while(\sim st.empty\ \&\ !\ used[s[i]]\ \&\ s[stack.peek] > s[i]\ \&\ remains[stack.peek] > 0):$

            $used[stack.pop] \coloneqq false$

        $if(stack.size < distincts):$

            $stack.push(i)$

            $onstack[s[i]] = true$

  $re = ""$

  $while(\sim st.empty): re \coloneqq re + s[st.pop]$

  $return\ reverse(s)$

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

$$\star\ or\ /\ >\ +,-$$
$$)\ >\ ($$

II. only +, -, *, /

$i \leftarrow 0, le \leftarrow exp.length$

$while(i < le \;\&\; exp[i] == \backslash s)\; i \leftarrow i + 1$

$if(i == le): return\; 0$

$first \leftarrow 0$

$while(i < le \;\&\; exp[i] \in [0,9]): first \leftarrow first * 10 + (exp[i + +] - '0')$

$if(i == le): return\; first$

$result = first, update = first$

$while(i < le):$

    $while(i < le \;\&\; exp[i] == \backslash s): i \leftarrow i + 1$

    $if(i == le): break$

    $nb \leftarrow 0,\; * nb\; is\; short\; for\; number$

    $if(exp[i]\; is\; ' + '):$

        $while(i < le \;\&\; exp[i]\; isn't\; a\; digit): i := i + 1$

        $while(i < le \;\&\; exp[i]\; is\; a\; digit): nb \leftarrow nb \star 10 + (exp[i + +] - '0')$

        $result \leftarrow result + nb, update := +nb$

    $elif(exp[i]\; is\; ' - '):$

        $while(i < le \;\&\; exp[i]\; isn't\; a\; digit): i \leftarrow i + 1$

        $while(i < le \;\&\; exp[i]\; is\; a\; digit): nb \leftarrow nb * 10 + (exp[i + +] - '0')$

        $result \leftarrow result - nb, update := -nb$

    $elif(exp[i]\; is\; ' * '):$

        $while(i < le \;\&\; exp[i]\; isn't\; a\; digit): i \leftarrow i + 1$

        $while(i < le \;\&\; exp[i]\; is\; a\; digit): nb \leftarrow nb * 10 + (exp[i + +] - '0')$

        $result := result - update + update \star nb, update := update \star nb$

    $elif(exp[i]\; is\; '/'):$

        $while(i < le \;\&\; exp[i]\; isn't\; a\; digit): i \leftarrow i + 1$

        $while(i < le \;\&\; exp[i]\; is\; a\; digit): nb \leftarrow nb \star 10 + (exp[i++] - '0')$

        $result := result - update + \frac{update}{nb}, update := \frac{update}{nb}$

$return\; result$

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.

$for \left(i = \dfrac{n}{2} - 1; i \geq 0; \right):$

    ⋆ 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

$for(boundary\ cell: matrix):$

    $heap. offer(cell\{x, y, height\})$

$$visited[cell.x][cell.y] = true$$

$$while(heap.notempty):$$

$$\quad cell\ c = heap.pop()$$

$$\quad h = c.height$$

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

$$\quad\quad n_x, n_y = (c.x, c.y) + dirs[i]$$

$$\quad\quad if(visited[n_x, n_y] = false\ \&\ mat[n_x, n_y] < h):$$

$$\quad\quad\quad visited[n_x, n_y] = true$$

$$\quad\quad\quad water := water + h - mat[n_x, n_y]$$

$$\quad\quad\quad heap.push\left(cell(n_x, n_y, mat[n_x, n_y])\right)$$

$$return\ water$$

252. Meeting Rooms I Facebook

I: Given a list of $(start, end)$ conference time intervals, check if one can take all intervals.
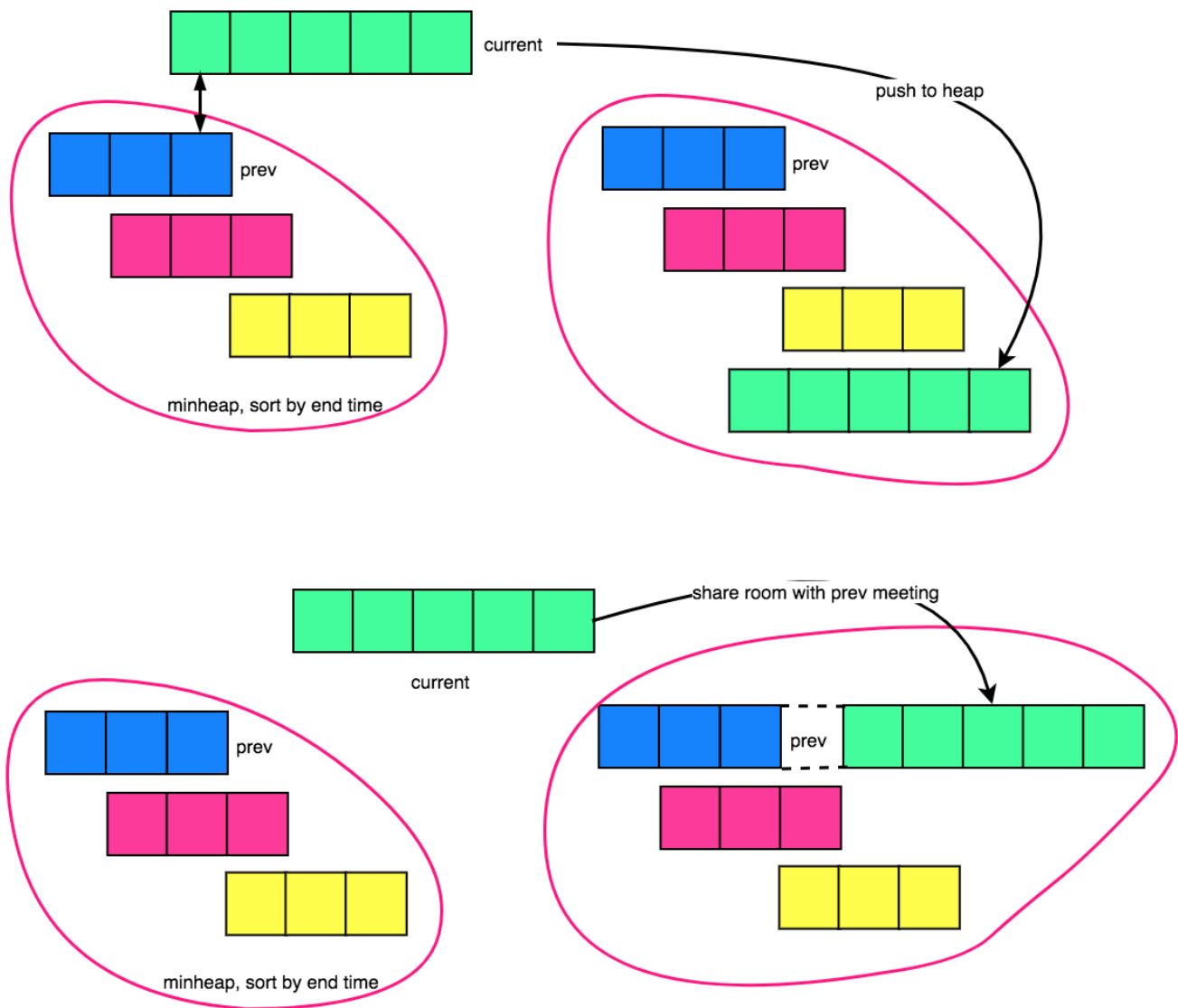
$$sort\ interval\ array\ by\ start\ time$$

$$for(i = 1; i < intervals.length;):$$

$$\quad if(interval_{i-1}.end > interval_i.start): return\ false$$

$$return\ true$$

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 1st 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 <mark>Uber</mark>

$Arrays.sort(array = arrive, size = n)$

$Arrays.sort(array = exit, size = n)$

$i = 1, j = 0, in = 1$

$while(i < n\ \&\ j < n)$

    $if(arrive[i] \leq exit[j])$:

        $in \leftarrow in + 1$

        $if(maxOverlap < in)$:

            $maxOverlap \leftarrow in$

            $map[maxOverlap].add(arrive[i])$

        $i = i + 1$

    $else$:

        $in = in - 1$

        $j = j + 1$

$return\ map[maxOverlap]$

Intuition & Algorithm #2

$timeLine[timestamp \Rightarrow overlapNum]$:$TreeMap$

$for(itv: intervals)$:

    $timeLine[itv.start] \coloneqq timeLine[itv.start] + 1$

    $timeLine[itv.end] \coloneqq timeLine[itv.end] - 1$

    $re = \max(timeLine[itv.start], re)$

$return\ re$

55. Jump Game I
45. Jump Game II Microsoft
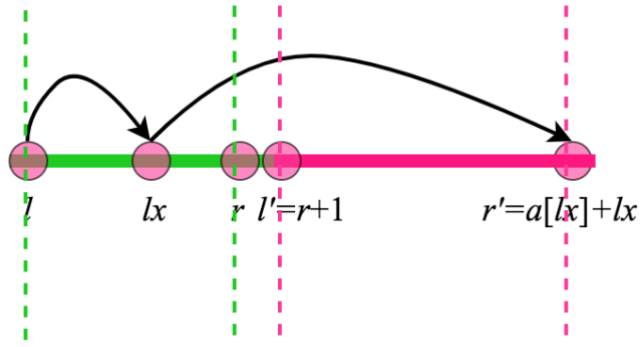
Intuition & Algorithm

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

$for(factor = 1 \rightarrow \lceil \sqrt{n} \rceil)$:

    $times \coloneqq \dfrac{n}{factor}$

    $remain \coloneqq mod(n, factor)$

    $if(remain = 0): re = max\{result, factor^{times}\}$

    $else: re = \max(re, factor^{times-1} * (remain + i), factor^{times} \star remain)$

---

397. Integer Replacement

$function(n)$:

    $if(n\ is\ odd)$:

        $if\left(\dfrac{(n+1)}{2} \& 1 == 0\right): return\ function(n + 1) + 1$

        $elif\left(\dfrac{n-1}{2} \& 1 == 0\right): return\ function(n - 1) + 1$

$$if(n \text{ is odd}): return \ function\left(\frac{n}{2}\right)$$

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

$List[List[int]] \ subsets(int[\ ] \ A):$

 $sort(A)$

 $List[int] \ load \coloneqq \{\phi\}$

 $List[List[int]] \ re \coloneqq \{\phi\}$

 $int \ idx \coloneqq -1$

 $dfs(A, idx, load, re)$

 $return \ re$

$void \ dfs(int[\ ] \ A, int \ idx, List[int] \ load, List[List[int]] \ re):$

 $re.add(new \ ArrayList(load))$

 $for(n_x \coloneqq idx + 1 \rightarrow len(A) - 1):$

  $if(n_x > idx + 1 \ \& \ A[n_x] = A[n_x - 1]): continue \rightarrow \textbf{\textit{important}}!! \ to \ avoid \ duplicates$

  $load.add(A[n_x])$

  $dfs(A, nx, load, re)$

  $load.remove(load.size - 1)$

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 $if(i > idx + 1 \ \& \ A[i] = A[i - 1]): continue$

$List\langle List\langle int\rangle\ \rangle\ combination \cdot sum(int[]\ A, int\ target):$

    $List\langle List\langle int\rangle\ \rangle\ result = new\ ArrayList\langle\rangle\ ()$

    $Arrays.sort(A)$

    $dfs(A, result, candidate = [\phi], sum = 0, target, idx = -1)$

    $return\ result$

$dfs(A, result, load, sum, target, idx)$

    $if(sum > target): return;$

    $if(sum = target): result.add(load), return$

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

        $if(i > idx + 1 \ \& \ A[i] = A[i-1]): continue$

        $load.add(A[i])$

        $dfs(A, result, load, sum + A[i], target, i)$

        $load.remove(load.size - 1)$

54. Spiral Matrix & II (59) Google Microsoft Uber

$while(true):$

    $for(j = left; j \le right;): print(a[top, j])$ *★ scan the top*

    $top := top + 1$ *★ remove the top ★*$, if(left > right \ || \ top > bottom): break;$

    $for(i = top; i \le bottom;): print(a[i, right])$ *★ scan the right*

    $right := right - 1$ *★ remove the right*$, if(left > right \ || \ top > bottom): break;$

    $for(j = right; j \ge left;): print(a[bottom, j])$ *★ scan the bottom*

    $bottom := bottom - 1$ *★ remove the bottom*$, if(left > right \ || \ top > bottom): break;$

    $for(i = bottom; i \ge top;): print(a[i, left])$ *★ 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

$boolean \ path \cdot sum(TreeNode \ o, int \ sum):$

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

    $if(o \ is \ a \ leaf): return \ sum = o.val$

    $if(path \cdot sum(o.l, sum + o.val) \ || \ path \cdot sum(o.r, sum + o.val)):$

        $return \ true$

    $return \ false$

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]

$reverse(a), reverse(b)$

$re = [len(a) + len(b)]$

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

    $for(j = 0 \rightarrow len(b) - 1):$

        $re[i + j] := re[i + j] + a[i] \star b[j]$

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

    $re[i + 1] := re[i + 1] + \frac{re[i]}{10}$

    $re[i] := mod(re[i], 10)$

$i := len(re) - 1$

$while(i \geq 1\ \&\ re[i] = 0): i := i - 1$

$for(; i \geq 0;): result \leftarrow result.append(arr_i)$

50. Pow(x, n)

$x^{11} = x^8 \star x^2 \star x^1$

```
pow(x, n):
    if (n = 0): return 1
    temp ← x
    while (n > 0):
        if (n & 2 = 1): re *= temp
        n = 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 · pow(a, b[])
    result = 1, a = mod(a, 1337)
    for(i = b.length − 1; i ≥ 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 (p_i.x = p_j.x & p_i.y = p_j.y): same+= 1
        elif (p_i.x = p_j.x) vertical+= 1
```
$$else: map \left\lceil \frac{[(p_i.y - p_j.y)]}{p_i.x - p_j.x} \right\rceil += 1$$

$$e = \max(same + \max(map \left\lceil \frac{[(p_i.y - p_j.y)]}{p_i.x - p_j.x} \right\rceil), vertical)$$

```
    result = max{result, e}
```

342. Power of Four <mark>Uber</mark>

$is \cdot power \cdot 4(int\ num)$:
$\quad double\ x = \log_4(num)$
$\quad double\ y = Math.floor(x)$
$\quad if\,(|x - y| < 10^{-6}): return\ true$
$\quad return\ false$
$double\ \log_4(int\ num)$:
$\quad return\ (\log_{10}(num))/\log_{10}(4)$

Solution II:

$4^n - 1 = (4 - 1)(4^{n-1} + 4^{n-2} + \cdots + 4^1 + 1) = 3K$

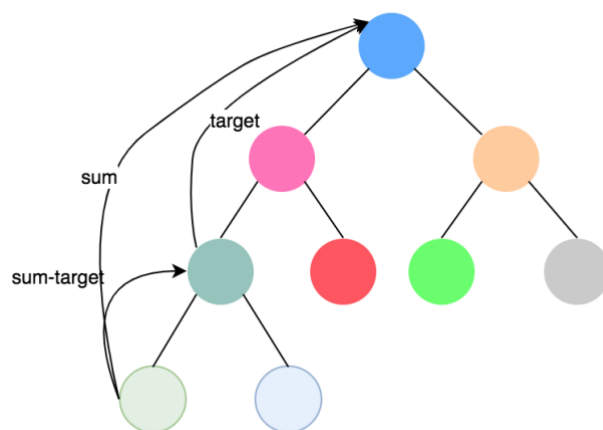$return\ num\ \&\ (num - 1) == 0\ and\ num > 0\ and\ (num - 1)\%3 == 0$

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.

$map[0] = 1$

$re = dfs(o, map, sum_{current} = 0, target)$

$dfs(TreeNode\ o, Map\langle int, int\rangle\ map, int\ sum_{current}, int\ target):$

    $if(o\ is\ null): return\ 0$

    $sum_{current} \coloneqq sum_{current} + o.val$

    $re \coloneqq re + map[sum_{current} - target]$

    $map[sum_{current}] \coloneqq map[sum_{current}] + 1$

    $re \coloneqq re + dfs(o.left, map, sum_{current}) + dfs(o.right, map, sum_{current})$

    $map[sum_{current}] \coloneqq map[sum_{current}] - 1$

    $return\ result$

Number of subarrays having sum exactly equal to k GeeksForGeeks

$int\ findSubarraySum(int[\ ]\ \mathcal{A}, int\ \mathcal{T}):$

    $map: Presum \Rightarrow counts$

    $re \coloneqq 0$

    $s \coloneqq 0$

    $map[0] \coloneqq 1$

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

        $s \coloneqq s + \mathcal{A}[i]$

        $re \coloneqq re + map[s - \mathcal{T}]$

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

    $return\ re$

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$\langle$K,V$\rangle:$

    $private$ Map$\langle$K, V$\rangle\ map$

```
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) ≫ 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 $A[i] = 0 \rightarrow -1$, then this problem is to find such a longest subarray whose sum equals to zero.

$$map := \{prefixsum \Rightarrow index\}$$

$$map[0] := -1$$

$$s := 0, re := 0$$

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

$$\quad s := s + (A[i] < 0) \rightarrow -1 : 1$$

$$\quad if (s = 0): re := \max(re, i)$$

$$\quad if (map[s] \neq nil): re := \max(re, i - map[s])$$

$$\quad \textcolor{red}{if (map[s] = nil)\ map[s] = i}$$

$$return\ re$$

325. Maximum Size Subarray Sum Equals k Facebook Palantir

$$mp: (type = (int \rightarrow int), default: mp[0] = -1)$$

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

$$\quad sum = sum + arr[i]$$

$$\quad if (mp[sum - k] \neq null): result = \max(result, i - mp[sum - k] + 1)$$

$$\quad \textcolor{blue}{if (mp[sum] == null):}$$

$$\quad\quad \textcolor{blue}{* if\ sum\ occurs\ more\ than\ once, only\ record\ the\ leftmost\ index\ asscociated\ with\ it}$$

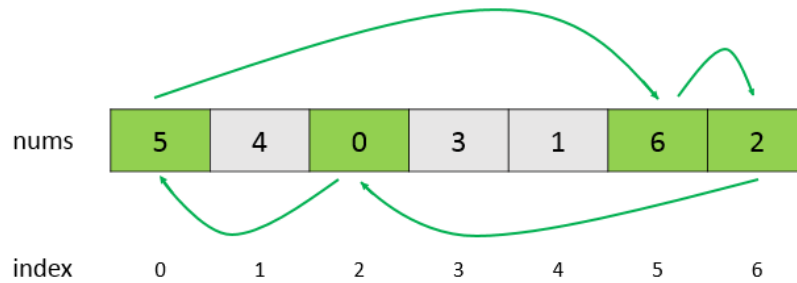$$\quad\quad \textcolor{blue}{mp[sum] = i}$$

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 $S[i] := \left(A[i], A[A[i]], A\left[A[A[i]]\right], \dots \right)$ subjected to the rule below.

i.e. $A = [5,4,0,3,1,6,2]$, $re = (A_0 = 5 \rightarrow A_5 = 6 \rightarrow A_6 = 2 \rightarrow A_2 = 0 \rightarrow A_0 = 5)$ 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 → len(A) − 1):
        if(used[i] = False):
            start := A[i], len := 1
            ⋆ Mark all number is a cirlce as visited
            do: start := A[start], len := len + 1, used[i] := True
            while(start ≠ A[i])
            re := max(re, len)
```

111

$$return\ re$$

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.

$List[int]\ numIslands(int\ m, int\ n, int[\ ][\ ]\ positions)$

    $re = [\phi], islands = 0, marked = \{\phi\}$

    $uf = UnionFind(m \star n)$

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

        $islands \coloneqq islands + 1$

        $x, y = positions[0], positions[1]$

        $id = x \star n + y$

        $marked.add(id)$

        $for(k = 0 \to len(dirs) - 1):$

            $n_x, n_y = x + dirs[i, 0], y + dirs[i, 1]$

            $if\left(n_x \in [0, m - 1]\ \&\ n_y \in [0, n - 1]\ \&\ marked[n_x \star n + n_y] = true\right):$

                $nextId = n_x \star n + n_y$

                $bool\ b = uf.union(id, nextId)$

                $if(b): islands \coloneqq islands - 1$

        $re.add(islands)$

128. Longest Consecutive Sequence
Solution I: hash-map

$for(int\ x: nums): set.add(x)$

$for(int\ x: nums):$

    $if(set[x] \neq null): continue$

    $l = x - 1$

    $while(set[l] \neq null): set[l] = null, l \coloneqq l - 1$

    $r = x + 1$

    $while(set[r] \neq null): set[r] = null, r \coloneqq r + 1$

    $set[x] = null$

    $result = \max(result, r - l)$

$find(i)$:

    $if(fa[i] \neq i): fa[i] = find(fa[i])$

    $return\ fa[i]$

$connect(i, j)$:

    $if((o_i = find(i)) \neq (o_j = find(j)))$:

        $if(rank[o_i] > rand[o_j]): fa[o_j] = o_i$

        $elif(rank[o_i] < rank[o_j]): fa[o_i] = o_j$

        $else: fa[o_i] = o_j, rank[o_i] \mathrel{+}= 1$

644. Maximum Average Subarray II Google

Find a subarray with a length ($\geq k$) 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.

$$\sum_{i}^{j} A[x]\ (j - i + 1 \geq k)$$

$$s.t.\ \frac{\sum_{i}^{j} A[x]}{(j - i + 1)} \geq avg\ or\ \sum(arr[k] - avg)\ \geq 0.$$

$boolean\ check(double\ avg_{est}, nums, k)$:

    $sum = 0.0$

    $for(i = 0 \to k - 1): sum = sum + nums[i] - avg_{est}$

    $if(sum \geq 0.0): return\ true$

    $pre_{sum} = 0.0, mi_{presum} = 0.0$

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

        $sum = sum + (nums[i] - avg_{est})$

        $pre_{sum} = pre_{sum} + (nums[i - k] - avg_{est})$

        $min_{presum} = \min(min_{presum}, pre_{sum})$

        $if(sum - mi_{presum} \geq 0): return\ true$

    $return\ false$

$findMaxAverage(nums, k)$:

    $mi \coloneqq \min(nums[i]), mx \coloneqq \max(nums[i]), \forall i \in [0, len(nums) - 1]$

$$if(mi = mx): return\ mx$$
$$error = 2^{31} - 1, prev_{est} = 0.0$$
$$while(error > 10^{-6}):$$
$$\quad avg_{est} = \frac{mi+mx}{2}$$
$$\quad if\big(check(avg_{est}, nums, k)\big): mi = avg_{est}$$
$$\quad else: mx = avg_{est}$$
$$\quad error = |avg_{est} - prev_{est}|$$
$$\quad prev_{est} = avg_{est}$$
$$return\ mx$$

665. Non-decreasing Array Google

Check if an array can be non-decreasing by modifying at-most 1 element.
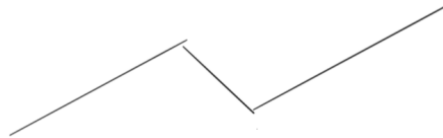
the above picture suggests an example of such array that making an array non-decreasing by modifying at-most one element.

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 → len(A) − 1): index[A[i] − 0] = i


    for(i = 0 → len(A) − 1):
        for(d = 9 → 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 ← i
    l ← largest * 2
    r ← largest * 2 + 1
    if(l < n & arr_l > arr_largest): largest ← l
    if(r < n & arr_r > arr_largest): largest ← r
    if(largest ≠ i)
        swap(arr, i, largest)
        heapify(arr, n, largest)
```

$$heap \cdot sort(arr)$$

$$build \cdot max \cdot heap \begin{cases} for\left(i = \frac{n}{2} − 1; i \geq 0;\right): \\ \quad heapify(arr, n, i) \end{cases}$$

$$for(i = n − 1; i \geq 0;)$$
$$\quad swap(arr, 0, i) \rightarrow remove\ the\ top$$
$$\quad heapify(arr, i, 0) \rightarrow maintain\ max \cdot heap\ for\ arr_0^{n-2}, arr_0^{n-3}, \cdots, arr_0^0)$$

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'

$$graph\ g \rightarrow \{\phi\}$$

$$for\big(word_i, word_j\ in\ words\big):$$

$$idx \leq \{word_i[id] \neq word_j[id], 0 \leq id < \min\Big(len\big(word_i, word_j\big)\Big)\}$$

$$add\ directed\ edge\ \{word_i[idx], word_j[idx]\}\ into\ g$$

$$do\ toppogical\ sort\ on\ g$$

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

$$List\langle int \rangle\ closetKvalues(TreeNode\ root, target):$$

$$List\langle int \rangle result = \{\phi\}$$

$$findLeft(root.left, target, lc(type = stack))$$

$$findRight(root.right, target, rc(type = stack))$$

$$while(result.size() < k):$$

$$if(lc.isEmpty()): result.add(rc.pop())$$

$$elif(rc.isEmpty()): result.add(lc.pop())$$

$$elif(|lc.peek() - target| < |rc.peek() - target|): result.add(lc.pop())$$

$$else: result.add(rc.pop())$$
$$return\ result$$

$$findLeft(TreeNode\ root, target):$$
$$\quad if(root == null): return$$
$$\quad findLeft(root.right, target, lc)$$
$$\quad lc.push(root.val)$$
$$\quad if(target < root.val): return$$
$$\quad findLeft(root.left, target, lc)$$

Solution 2. flatten BST into sorted list, then find k closet node on list

$$static\ TreeNode\ head = null$$
$$static\ TreeNode\ prev = null$$
$$flatten(TreeNode\ root):$$
$$\quad if(root == null): return$$
$$\quad flatten(root.left)$$
$$\quad if(head == null):$$
$$\quad\quad head = root$$
$$\quad\quad prev = root$$
$$\quad else:$$
$$\quad\quad prev.right = root$$
$$\quad\quad root.left = prev$$
$$\quad\quad prev = root$$
$$\quad flatten(root.right)$$

$$List\langle int\rangle\ findkcloset(int\ target, int\ k):$$
$$\quad result = \{\phi\}$$
$$\quad TreeNode\ p = findNodeCloset2Target(head, target)$$
$$\quad if(p.left == null): result.add(p \to p.right + k - 1)$$
$$\quad elif(p.right == null): result.add(p \to p.left - l + 1)$$
$$\quad else:$$
$$\quad\quad l = p.left, r = p.right, result.add(p.val)$$
$$\quad\quad while(result.size() < k):$$
$$\quad\quad\quad if(|l.val - target| \le |r.val - target|):$$

$$result.add(l.val), l = l.left$$
$$else: result.add(r.val), r = r.right$$
$$return\ result$$

Graph & Topo-sort & Union-Find

127. Word Ladder & II (126) Uber Zillow

$$Queue\ Q \leftarrow \{Node(begin_{word}, 1)\}$$
$$word_{dict}.add(end_{word})$$
$$while(Q.size > 0):$$
$$\quad Node\ top \leftarrow Q.poll$$
$$\quad word \leftarrow top.word, level \leftarrow top.level$$
$$\quad if(word = end_{word})\ return\ true$$
$$\quad for(i = 0 \rightarrow len(word) - 1):$$
$$\quad\quad for(c = a \rightarrow z):$$
$$\quad\quad\quad if(word[i] \neq c):$$
$$\quad\quad\quad\quad temp = word[i], word[i] = c, str_{new} = String(word[i])$$
$$\quad\quad\quad\quad if(word_{dict}[str_{new}] \neq null):$$
$$\quad\quad\quad\quad\quad Q.offer(Node(str_{new}, level + 1))$$
$$\quad\quad\quad\quad\quad word_{dict}.remove(str_{new})$$
$$\quad\quad\quad\quad word_i = temp\ \textcolor{blue}{\#backtrack}$$
$$return\ false$$

Interview Q. Bipartite graph check Uber

$$queue.offer(node\{src, color = 0\})$$
$$while(queue.is\ not\ empty):$$
$$\quad node\ nd = queue.pop$$
$$\quad u = nd.vertex, color = nd.color$$
$$\quad if(matrix[u][u] == 1): return\ false$$
$$\quad for(v: u.adjacent\ nodes):$$
$$\quad\quad if(color[v] == 1 - color): continue$$
$$\quad\quad elif(matrix[u][v] == none): queue.offer(node\{v, 1 - color\})$$

$$elif(matrix[u][v] == red): return\ false$$

$$return\ true$$

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.

$int\ minMutation(String\ start, String\ end, String[\ ]\ bank):$

   $if(len(bank) = 0): return - 1$

   $Queue[String]\ que = \{\phi\}, Set[String]\ genebank = \{bank\}, Set[String]\ used = \{\phi\}$

   $level = 0$

   $while(que.size > 0):$

      $size = que.size$

      $used.addAll(que)\ \star\ \mathcal{Mark}\ all\ string\ on\ current\ level\ as\ visited$

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

         $String\ gene = que.poll$

         $if(gene = end): return\ level$

         $char[\ ]\ chars = gene.toCharArrayv$

         $for(j = 0 \rightarrow len(chars) - 1):$

            $for(k = 0 \rightarrow len([A, C, G, T]) - 1):$

               $if(chars[j] \neq elements[k]):$

                  $swap(chars[j], elements[k])$

                  $String\ genex = String(chars)$

                  $if(geneBank[genex] \neq nil\ \&\ used[genex] \neq nil):$

                     $que.offer(genex), used.add(genex)$

                  $swap(chars[j], elements[k])$

      $level \coloneqq level + 1$

   $return - 1$

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.

$List[int]\ findMinHeightTrees(int\ n, int[\ ][\ ]\ edges):$

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

    $g: Map[int, Set[int]], ind = [n], List[int]\ re = [\phi]$

```
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
```

$$gcd(x, y):$$
$$\quad if\,(y = 0): return\,x$$
$$\quad else: return\,gcd(y, x \,\%\, y)$$

367. Valid Perfect Square LinkedIn

Given a positive integer, determine if the given number is perfect square or not.

Intuition & Algorithm

$$bool\,isPerfectNum(int\,x):$$
$$\quad if\,(num \le 0): return\,false$$
$$\quad low := 1, high := x$$
$$\quad while\,(low < high):$$
$$\quad\quad mid := \frac{low+high}{2}$$
$$\quad\quad if\left(\frac{x}{mid} > mid\right): low := mid + 1$$
$$\quad\quad else: high := mid$$
$$\quad return\,low^2 = x$$

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, $1 \to A, 2 \to B, \cdots, 26 \to Z, 27 \to AA, 28 \to AB$

$$string\,convertToTitle(int\,n):$$
$$\quad re := ""$$
$$\quad while\,(n > 0):$$
$$\quad\quad r := mod(n, 26)$$
$$\quad\quad if\,(r = 0): re := "Z" + re$$
$$\quad\quad else: re := (char)('A' + r - 1) + re$$
$$\quad\quad n := \frac{n}{26}$$
$$\quad\quad if\,(r = 0): n := n - 1$$

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 × 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 += BA×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

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

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

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

$power(int\ F[][], int\ n):$

    $if(n \leq 1)\ return;$

    $power(F,\ n/2):$

    $multiply(F, F)$

    $if(n\&1 == 1)\ multiply(F, M)$

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

$fractionToDecimal(int\ n, int\ d):$

    $StringBuilder\ sb\ =\ new\ StringBuilder();$

    $if\big((n > 0\ \&\ d < 0)\ ||\ (n < 0\ \&\ d > 0)\big): sb.append("-")$

    $long\ num\ =\ (long)|n|, den\ =\ (long)\ |d|$

    $sb.append\left(Long.toString\left(\frac{num}{den}\right)\right) \textit{the integer part}$

    $num\ \%=\ den$

    $if(num > 0)\ sb.append(.)$

    $map\langle long, int\rangle\ ls \rightarrow \textit{map remainder to decimal index}$

    $p = 0, ls[num] = sb.length()\left(i.e.\frac{20}{3} = 6.\cdots, remainder = 2\right), ls[2] = len('6.') = 2$

    $while(num > 0):$

        $num \coloneqq num \star 10, sb.append\left(\frac{num}{den}\right), num \coloneqq mod(num, len)$

        $if(ls[num] \neq null)$

            $idx \coloneqq ls[num])$

            $sb.insert(idx, '(')$

            $sb.append(')')$

            $break$

        $else: ls[num] = len(sb)$

    $return\ sb.toString()$

29. Divide two Integers

526. Beautiful Arrangement

$dfs(N, index, used, count)$

    $if(index > N):$

        $count = count + 1, return$

    $for(i = 1 \rightarrow N):$

        $used[i] = true$

$$dfs(N, index + 1, used, count)$$
$$used[i] = false$$

---

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, $-12.35789e^{+456}$

$regex = [-+]?(\d+\.?\ |\ \.\d+)\d*(e[-+]?\d+)?$

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.

$String\ replaceWords(List\langle String\rangle\ dict, String\ sentence):$

$$String[]\ words \leftarrow sentence.split("\ ")$$

$$buildTrie(dict)$$

$$result \leftarrow ""$$

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

$$\quad TrieNode\ p \leftarrow root$$

$$\quad j \leftarrow 0$$

$$\quad for(;j < words[i].length();):$$

$$\quad\quad if(p.next[words[i][j]-'a'] \neq null):$$

$$\quad\quad\quad p \leftarrow p.next[words[i][j]-'a']$$

$$\quad\quad\quad if(p.isWord):break$$

$$\quad\quad else:break$$

$$\quad if(p.isWord):result \leftarrow result + \ words[i].substring(0,j+1)$$

$$\quad else:result \leftarrow result + words[i]$$

$$\quad if(i < words.length - 1):result \leftarrow result + "\ "$$

412. Fizz Buzz

415. Add Strings

$$char[]a \leftarrow new\ StringBuffer(num_1).reverse().toString().toCharArray()$$

$$char[]b \leftarrow new\ StringBuffer(num_2).reverse().toString().toCharArray()$$

$$len \leftarrow a.length > b.length?\ a.length:b.length$$

$$result \leftarrow array_{1d}(size = len + 1)$$

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

$$\quad a_i \leftarrow i < a.length?\ a_i:0$$

$$\quad b_i \leftarrow i < b.length?\ b_i:0$$

$$\quad result_i \leftarrow a_i + b_i$$

$$for(i = 0 \rightarrow len - 2):$$

$$\quad result_{i+1} \leftarrow result_{i+1} + result_i/10$$

$$\quad result_i = result_i\ mod\ 10$$

$$i \leftarrow len - 1, output = ""$$

$$while(i \geq 1 \, \& \, result_i == 0) i \leftarrow i - 1$$

$$for(; i \geq 0;): output \leftarrow output + result_i$$

$$return \; output$$

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

$$char[] \; ca \leftarrow a.reverse().toCharArray()$$

$$char[] \; cb \leftarrow b.reverse().toCharArray()$$

$$i = 0, j = 0$$

$$len = \max(ca.length, cb.length), int[] \; re = [len]$$

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

$$\quad int \; a_i = i < ca.length? \, ca[i] - '0': 0;$$

$$\quad int \; b_i = i < cb.length? \, cb[i] - '0': 0;$$

$$\quad re_i = a_i + b_i$$

$$for(i = 0 \rightarrow len - 2):$$

$$\quad re[i+1] \coloneqq re[i+1] + \frac{re[i]}{10}$$

$$\quad re[i] \coloneqq mod(re[i], 10)$$

$$i = len - 1$$

$$for(; i \geq 1 \, \& \, re[i] = 0; i \coloneqq i - 1); \textcolor{red}{\Rightarrow \textit{remove unnecessary leading zeros}}$$

$$result = ""$$

$$for(; i \geq 0; --i): result.append(re[i] + '0')$$

$$return \; result$$

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

$re = \{\phi\}$
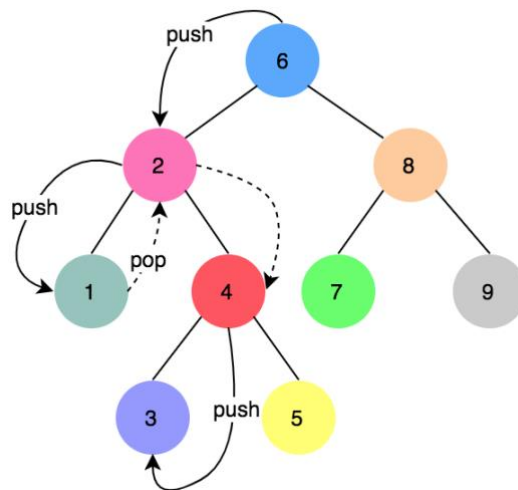
$Stack[TreeNode]\ st = \{\phi\}$

$TreeNode\ node := root$

$while(node \neq nil):$

```
        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)
```

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

$$ListNode\ p \leftarrow head$$

$$while(p \neq null):$$

$$\quad if(p.next == null): break;$$

$$\quad ListNode\ q \leftarrow p.next$$

$$\quad while(q \neq null\ \&\ q.val == p.val): q \leftarrow q.next$$

$$\quad p.next \leftarrow q$$

$$\quad p \leftarrow q$$

$$return\ head$$

II. Remove all duplicated number only remain single number

$$ListNode\ deleteDuplicates \cdot 2(ListNode\ head)$$

$$ListNode\ dummy \leftarrow new\ ListNode(-1)$$

$$dummy.next \leftarrow head$$

$$ListNode\ p \leftarrow dummy, q = dummy.next$$

$$while(q \neq null):$$

$$\quad while(q.next \neq null\ \&\ q.next.val == q.val)\ q = q.next$$

$$\quad if(p.next == q):$$

$$\quad\quad p = p.next, q = q.next$$

$$\quad else:$$

$$\quad\quad p.next = q.next$$

$$\quad\quad q = p.next$$

242. Valid Anagram

$$count(type = array, size = 26, default = 0)$$

$$if(s.length() \neq t.length()): return\ false$$

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

$$\quad counter[s[i]] += 1$$

$$\quad counter[t[i]] -= 1$$

$$for(i = 0 \rightarrow 25):$$

$$\quad if(counter[i] \neq 0): return\ false$$

$$return\ true$$

147. Insertion Sort List

148. Sort List

$ListNode\ sortList(ListNode\ head):$

    $if(head == nil\ or\ head.next == nil): return\ head$

    $ListNode\ prev = nil, slow = head, fast = head$

    $while(fast \neq nil\ and\ fast.next \neq nil):$

        $prev = slow$

        $slow = slow.next$

        $fast = fast.next.next$

    $prev.next = nil \star very\ important, to\ cut\ down\ one\ list\ into\ two\ halves$

    $ListNode\ left = sortList(head)$

    $ListNode\ right = sortList(slow)$

    $return\ merge(left, right)$

$merge(left, right):$

    $ListNode\ head = (-1), r = head$

    $while(left \neq nil\ and\ right \neq nil):$

        $if(left.val \leq right.val):$

            $r.next = left, r = r.next$

        $else: r.next = right, r = r.next$

    $while(left \neq nil): r.next = left, left = left.next, r = r.next$

    $while(right \neq nil): r.next = right, right = right.next, r = r.next$

    $return\ head.next$

387. First Unique Character in a String

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

    $counter[str[i] - 'a'].freq += 1$

    $if(counter[str[i] - 'a'].freq == 1): counter[str[i] - 'a'].firstIdx = i$

$for(i = 0 \rightarrow 25):$

    $if(counter[i].freq = 1\ \&\ counter[i].firstIdx < result):$

        $result = counter[i].firstIdx$

$return\ result$

290. Word Pattern I & II (291) <mark>Uber</mark>

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 $O(n * (n - 1) * \cdots * 1 = n!, n\ factorial)$

$boolean\ wordPatternMatch(pattern, str):$

    $if(pattern.length\ is\ 0\ \&\ str.length\ is\ also\ 0): return\ true$

    $if(pattern.length\ is\ 0): return\ false$

    $map\langle char, str\rangle\ char2str, set\langle str\rangle\ vis$

    $return\ check(pattern, 0, str, 0, char2str, vis)$

```
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

$merge(int[\ ]\ A, m, int[\ ]\ B, n)$:

    $i = m - 1, m := m - 1, n := n - 1$

    $while(m \geq 0\ \&\ n \geq 0)$:

        $if(A[m] \geq B[n]): A[i] := A[m], i := i - 1, m := m - 1$

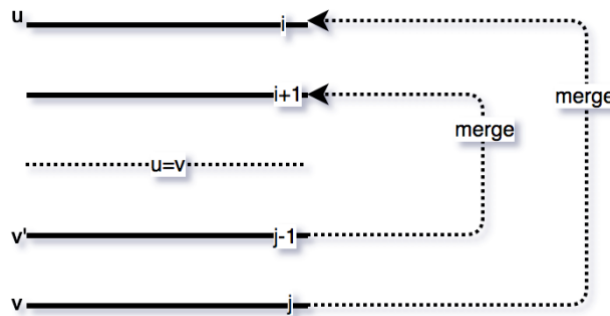 $else: A[i] := B[n], i := i - 1, n := n - 1$

    $while(n \geq 0): A[i] := A[n], i := i - 1, n := n - 1$

---

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

$$result \leftarrow \{\phi\}$$
$$for(i = 1 \rightarrow n):$$
$$\quad if(mod(i, 3) == 0\ \&\ mod(i, 5) \neq 0): result.add('fizz')$$
$$\quad elif(mod(i, 3) \neq 0\ \&\ mod(i, 5) == 0): result.add('buzz')$$
$$\quad elif(mod(i, 15) == 0): result.add('fizzbuzz')$$
$$\quad else: result.add((char)(i + '0'))$$

758. Bold Words in String Google

Solution I: $Time\ complexity: O(n \star m \star k), m = dict.size, k = avg(word[i].length)$

$$its(Interval) = \{\}$$
$$for(i = 0 \rightarrow n - 1):$$
$$\quad for(word: dict):$$
$$\quad\quad if\big(s.startsWith(word, i)\big): its.add\big(new\ Interval(i, i + word.length - 1)\big)$$
$$its = merge \cdot intervals(its)$$
$$for(Interval\ it: its):$$
$$\quad for(i = it.start \rightarrow it.end): bold[i] = true$$
$$for(i = 0 \rightarrow n - 1):$$
$$\quad if\big(bold[i]\ and\ (i == n - 1\ or\ !bold[i + 1])\big): result \leftarrow result + "\langle/b\rangle"$$
$$\quad result \leftarrow result + s_i$$
$$\quad if\big(bold[i]\ and\ (i == n - 1\ or\ !bold[i + 1])\big): result \leftarrow result + "\langle/b\rangle"$$
$$return\ result$$

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 $s[i:i] \rightarrow s[i:i+9]$, then the time complexity can be reduced from $O(n^3) \rightarrow O(nL^2)$ where $L = \max\big(len(word_i)\big)$

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

 $for(l = \min(n - i, kMaxWordLen = 10) \rightarrow 1)$:

  $if\big(dict[s_{i,l}] \neq null\big)$:

   $for(k = i \rightarrow i + l): bold[k] = true$