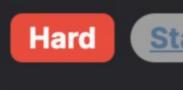
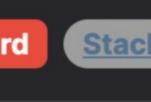
self.mx to ensure it's always the highest frequency we've encountered so far.





Problem Description



regular stack, which simply adds elements to the top and removes them from the top in a LIFO (Last In First Out) manner, this stack has the additional functionality of popping the most frequently occurring element. In case of a tie in frequency, the element closest to the top should be popped.

The problem asks for the design of a special kind of stack that keeps track of the frequency of elements as they are pushed. Unlike a

Intuition

To solve this problem, we must maintain a frequency map and a map for elements by frequency. For this, two hashmaps are used: one to count the instances (self.cnt) of each value and another (self.d) to store values grouped by their instance count. Additionally, we keep track of the maximum frequency (self.mx) among all elements in the stack at any given time.

• When push is called, we increase the count of the element and update the element's group by frequency. We also update the

- Conversely, when pop is called, we need to retrieve and return the most frequent element, which is at the end of the list in the self.d dictionary for the maximum frequency. After removing the element, we decrease its count in self.cnt. Should the list for this frequency be empty afterward, it means we no longer have elements with this highest frequency, so we decrement self.mx.
- The key to the solution is making sure that both push and pop operations are done in O(1) average time complexity, which is achieved through the use of the hashmaps and keeping track of the maximum frequency dynamically.

The implementation of the FreqStack utilizes hash maps, a commonly used data structure in algorithm design for achieving efficient, average O(1) time access and manipulation of data.

Solution Approach

1. Initialization (__init__ method): self.cnt: A defaultdict(int) which maps each value to its frequency of occurrence in the stack.

2. Push Operation (push method):

The FreqStack class is structured as follows:

- Increment the frequency count of the value val being pushed in self.cnt. Append val to the list in self.d that corresponds to this new frequency count.
- Update self.mx to reflect the maximum frequency count if the frequency of val is the new maximum. 3. Pop Operation (pop method):

Identify the value val that needs to be popped, which is the last element in the list at self.d[self.mx].

o If the list at the current maximum frequency is now empty, decrement self.mx as there are no longer any elements with this

self.d: A defaultdict(list) which maps frequencies to a list of values that have that frequency.

• self.mx: An integer keeping track of the current maximum frequency of any element in the FreqStack.

- Pop this value from the list. Decrement the frequency count of the value val in self.cnt.
 - frequency. • Return the value val.
- By using these structures, we can ensure that the push operation is conducted by simply incrementing the count and appending to a list, and the pop operation is a matter of popping from a list and updating counts. Both operations avoid any time-consuming

searches or iterations, allowing for fast execution.

This approach elegantly handles the requirements of popping the most frequent element, and in the case of a tie, the element

nearest to the top, all while maintaining average O(1) time complexity for both push and pop operations.

Example Walkthrough Let's consider a scenario where we operate on a FreqStack object to illustrate the solution approach described above. 1. Initialize the FreqStack object.:

 self.mx would be initialized to 0, indicating no elements are in the stack yet 2. Perform several push operations:

push(5): self.cnt[5] becomes 1 since 5 is now pushed once. self.d[1] now contains [5]. self.mx is updated to 1.

At this point, our frequency map self.cnt looks like this: {5: 3, 7: 2} and our elements by frequency map self.d looks like this:

• We need to pop the most frequent element. According to self.mx, the most frequent elements are in the list self.d[3],

o self.mx: 2

Python Solution

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/**

*/

public int pop() {

def __init__(self):

self.max_freq = 0

def pop(self) -> int:

def push(self, val: int) -> None:

self.freq_counter[val] -= 1

push(7): self.cnt[7] is incremented to 2. self.d[2] becomes [5, 7]. self.mx stays 2. push(5): self.cnt[5] is incremented to 3. self.d[3] now has [5]. self.mx is updated to 3.

• We pop 5 from self.d[3], which then becomes an empty list. Now, self.cnt[5] is decremented to 2.

push(7): self.cnt[7] becomes 1. self.d[1] becomes [5, 7]. self.mx stays 1.

{1: [5, 7], 2: [5, 7], 3: [5]}. The current maximum frequency self.mx is 3.

o push(5): self.cnt[5] is incremented to 2. self.d[2] now has [5]. self.mx is updated to 2.

3. Perform a pop operation:

which currently has [5].

self.cnt would be an empty defaultdict(int)

self.d would be an empty defaultdict(list)

The popped element is 5. After the pop, the structures are: o self.cnt: {5: 2, 7: 2} o self.d: {1: [5, 7], 2: [5, 7]}

Continuing to push and pop using the same approach, the FreqStack will maintain the frequency of elements and allow us to pop the

most frequent element quickly, or the latest pushed element among the most frequent when there's a tie, achieving the average O(1)

- time complexity for both operations.
 - from collections import defaultdict class FreqStack:

Decrement the frequency count for that value

// Update the maxFrequency if necessary.

// then reduce the maximum frequency.

maxFrequency--;

return value;

* int param_2 = obj.pop();

* obj.push(val);

// Return the popped element.

* The FregStack class is used like this:

* FregStack obj = new FregStack();

maxFrequency = Math.max(maxFrequency, currentFrequency);

int value = frequencyStackMap.get(maxFrequency).pop();

// Decrement the frequency count of the popped element.

frequencyMap.put(value, frequencyMap.get(value) - 1);

if (frequencyStackMap.get(maxFrequency).isEmpty()) {

// Method to pop and return the most frequent element from the stack.

// Pop the element from the stack with the maximum frequency.

// If there is a tie, it returns the element closest to the stack's top.

// If the stack corresponding to the maximum frequency is empty,

self.freq counter = defaultdict(int)

self.freq_dict = defaultdict(list)

Initialize a dictionary to count the frequency of elements

Variable to keep track of the maximum frequency observed so far

A dictionary that maps frequencies to a list of elements with that frequency

Pops and returns the most frequent integer from the stack. If there is a tie,

Since self.d[3] is empty, we decrement self.mx to 2.

Pushes an integer onto the stack and updates the structures tracking element frequency. 14 15 # Increment the frequency count for the given value 16 self.freq_counter[val] += 1 # Add the value to the list of values that have the new frequency count self.freq_dict[self.freq_counter[val]].append(val) 19 # Update the maximum frequency if it's exceeded by this value's frequency 20 21 self.max_freq = max(self.max_freq, self.freq_counter[val])

If there are no more elements with the current maximum frequency, decrease the maximum frequency

26 it returns the integer closest to the top of the stack. 27 # Pop the value from the list corresponding to the maximum frequency 28 val = self.freq_dict[self.max_freq].pop()

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33
           if not self.freq_dict[self.max_freq]:
34
               self.max_freq -= 1
35
           # Return the value
36
           return val
37
38
39 # How to use the FregStack class
40 # obj = FreqStack()
41 # obj.push(val)
  # param_2 = obj.pop()
43
Java Solution
  import java.util.HashMap;
2 import java.util.Map;
   import java.util.Deque;
   import java.util.ArrayDeque;
6 // Class to define a stack-like data structure that supports push and pop
   // operations based on the frequency of elements.
8 class FreqStack {
       // A map to store the frequency of each element.
       private Map<Integer, Integer> frequencyMap = new HashMap<>();
10
       // A map to store stacks corresponding to each frequency.
11
       private Map<Integer, Deque<Integer>> frequencyStackMap = new HashMap<>();
12
       // Variable to store the current maximum frequency.
13
       private int maxFrequency;
14
15
       // Constructor for the FreqStack class.
16
17
       public FreqStack() {
           // Initialize the maxFrequency to 0.
18
           maxFrequency = 0;
19
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22
       // Method to push an integer onto the stack.
23
       public void push(int val) {
24
           // Increase the frequency of the value by 1.
25
           frequencyMap.put(val, frequencyMap.getOrDefault(val, 0) + 1);
26
           // Get the updated frequency of the value.
           int currentFrequency = frequencyMap.get(val);
28
           // Add the value to the stack corresponding to its frequency.
           frequencyStackMap.computeIfAbsent(currentFrequency, k -> new ArrayDeque<>()).push(val);
29
```

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C++ Solution
   #include <unordered map>
 2 #include <stack>
  #include <algorithm>
   using namespace std;
   class FreqStack {
   public:
       FreqStack() {
           // Constructor initializes the FregStack object.
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       void push(int val) {
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           // Increment the frequency count of the pushed value.
            frequencyMap[val]++;
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15
           // Push the value into the corresponding frequency stack.
16
           frequencyStackMap[frequencyMap[val]].push(val);
18
           // Update the maximum frequency.
19
           maxFrequency = max(maxFrequency, frequencyMap[val]);
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       int pop() {
24
           // Get the value from the top of the maximum frequency stack and
25
           // pop it from the stack.
           int value = frequencyStackMap[maxFrequency].top();
26
27
            frequencyStackMap[maxFrequency].pop();
28
           // Decrement the frequency count of the popped value.
            frequencyMap[value]--;
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           // If the current maximum frequency stack is empty, decrement the
33
           // maximum frequency.
34
           if (frequencyStackMap[maxFrequency].empty()) {
35
               maxFrequency--;
36
37
38
           // Return the popped value.
39
           return value;
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41
   private:
       unordered_map<int, int> frequencyMap; // Maps value to its frequency.
43
       unordered_map<int, stack<int>> frequencyStackMap; // Maps frequency to a stack containing values with that frequency.
44
       int maxFrequency = 0; // The current maximum frequency among all values.
46 };
47
   /**
    * The FregStack object is instantiated and used as shown below:
    * FreqStack* obj = new FreqStack();
    * obj->push(val); // Pushes an element onto the stack.
    * int param_2 = obj->pop(); // Pops and returns the most frequent element. If there is a tie, it returns the element closest to the
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```

frequencyStackMap[frequency].push(val); 33 34 35 // Update maxFrequency if necessary. 36 maxFrequency = Math.max(maxFrequency, frequency); 37 } 38

function pop(): number {

maxFreqStack.pop();

frequencyMap[value] -= 1;

maxFrequency -= 1;

return value;

initializeFreqStack();

// Return the popped value.

Typescript Solution

11 let maxFrequency: number = 0;

maxFrequency = 0;

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59 }

19 }

import { Stack } from 'stack-typescript';

13 // Initializes the global data structures.

const frequency = frequencyMap[val];

if (!frequencyStackMap[frequency]) {

14 function initializeFreqStack(): void {

22 function push(val: number): void {

const frequencyMap: Record<number, number> = {};

Time and Space Complexity **Time Complexity**

• __init__(): The time complexity is 0(1) as it only initializes variables.

// Importing the necessary data structures from JavaScript's standard library

// Define a global variable to keep track of the current maximum frequency.

// Reset frequencyMap and frequencyStackMap for a new FreqStack instance.

for (const key in frequencyStackMap) delete frequencyStackMap[key];

// Define a global variable to map frequencies to stacks that hold values with those frequencies.

// If frequencyStackMap doesn't already have a stack for the new frequency, create one.

// Defines the pop method to remove and return the most frequent value from the FreqStack.

// To mimic class instantiation with global scope we invoke initializeFreqStack to start.

// Check if the value is already in frequencyMap, increment its count, otherwise add it with a count of 1.

// Define a global variable to track the frequency of each value.

const frequencyStackMap: Record<number, Stack<number>> = {};

for (const key in frequencyMap) delete frequencyMap[key];

21 // Defines the push method to add a value to the FreqStack.

frequencyMap[val] = (frequencyMap[val] || 0) + 1;

frequencyStackMap[frequency] = new Stack<number>();

// Push the value onto the appropriate frequency stack.

// Retrieve the stack with the current max frequency.

const maxFreqStack = frequencyStackMap[maxFrequency];

// Decrease the frequency of the popped value in the frequencyMap.

// If the max frequency stack is now empty, decrement maxFrequency.

// Pop the most frequent value from this stack.

delete frequencyStackMap[maxFrequency];

const value = maxFreqStack.top();

if (maxFreqStack.size() === 0) {

- push(val): The time complexity is 0(1). The operation increments a counter, appends a value to a list, and updates a maximum value. Each of these operations is constant time as it doesn't depend on the size of the data structure.
- pop(): The time complexity is 0(1). It pops a value from the list corresponding to the maximum frequency, decrements the counter for the value, and decreases the maximum frequency if necessary. These operations are all constant time since the pop operation removes the last element of the list which is a constant time operation.

Space Complexity

 Overall space complexity for the FreqStack class is O(N), where N is the number of elements pushed into the stack. This is because the stack keeps track of all elements inserted, their counts, and the lists corresponding to each frequency.