75. Sort Colors

April 9, 2019 | 60.6K views

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Given an array with *n* objects colored red, white or blue, sort them **in-place** so that objects of the same color are adjacent, with the colors in the order red, white and blue.

Here, we will use the integers 0, 1, and 2 to represent the color red, white, and blue respectively.

Note: You are not suppose to use the library's sort function for this problem.

Example:

```
Input: [2,0,2,1,1,0]
Output: [0,0,1,1,2,2]
```

Follow up:

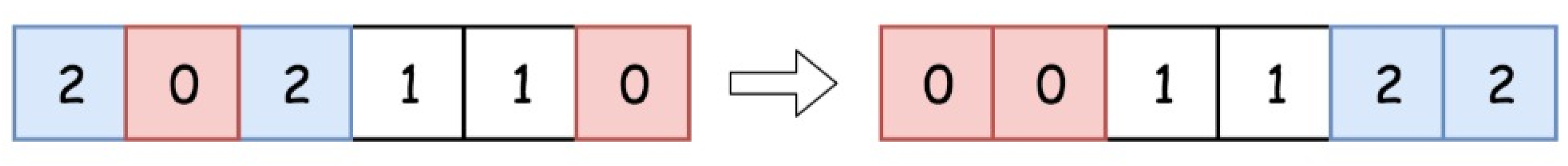
- A rather straight forward solution is a two-pass algorithm using counting sort.
  First, iterate the array counting number of 0's, 1's, and 2's, then overwrite array with total number of 0's, then 1's and followed by 2's.
- Could you come up with a one-pass algorithm using only constant space?

Solution

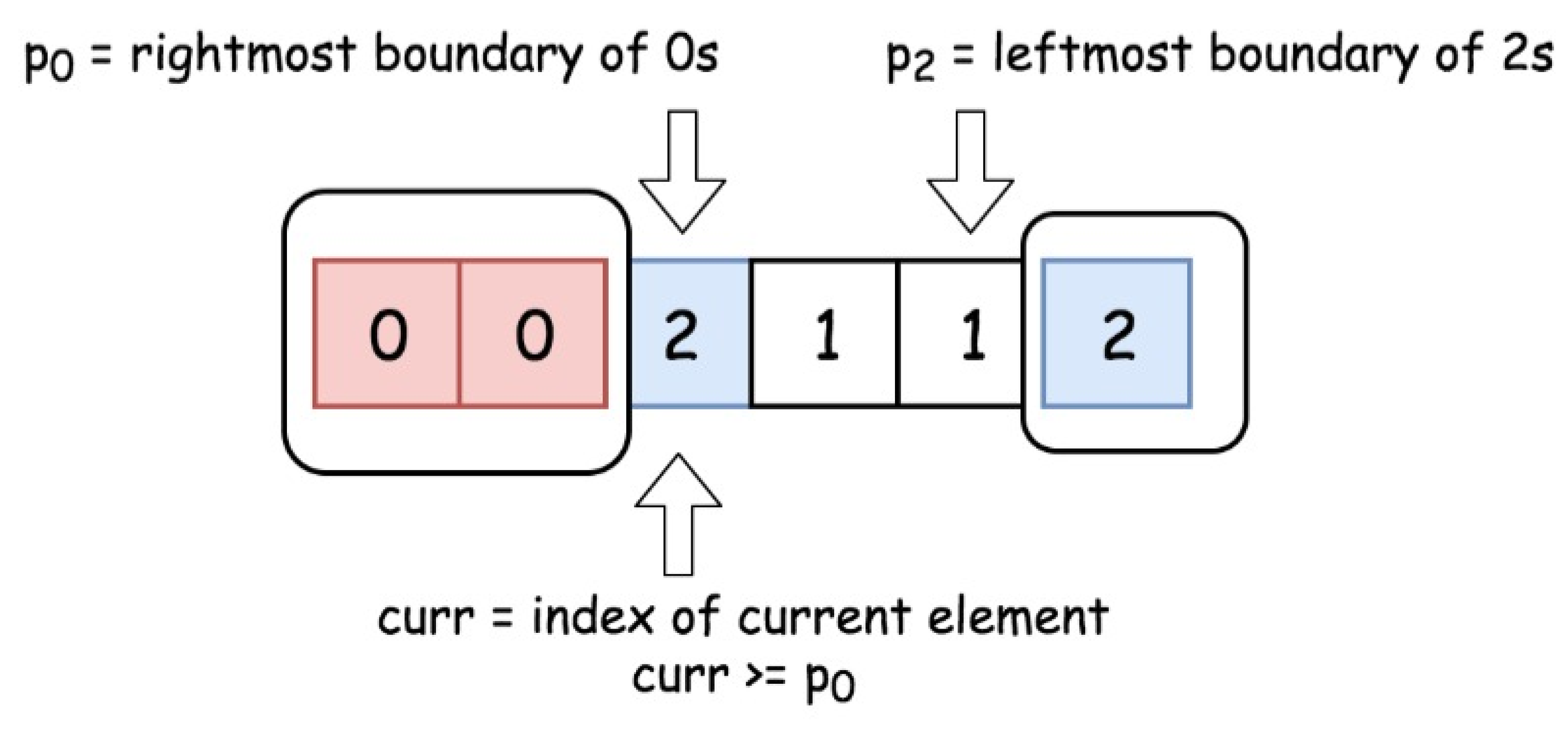
Approach 1: One Pass

Intuition

The problem is known as Dutch National Flag Problem and first was proposed by Edsger W. Dijkstra. The idea is to attribute a color to each number and then to arrange them following the order of colors on the Dutch flag.



Let's use here three pointers to track the rightmost boundary of zeros, the leftmost boundary of twos and the current element under the consideration.

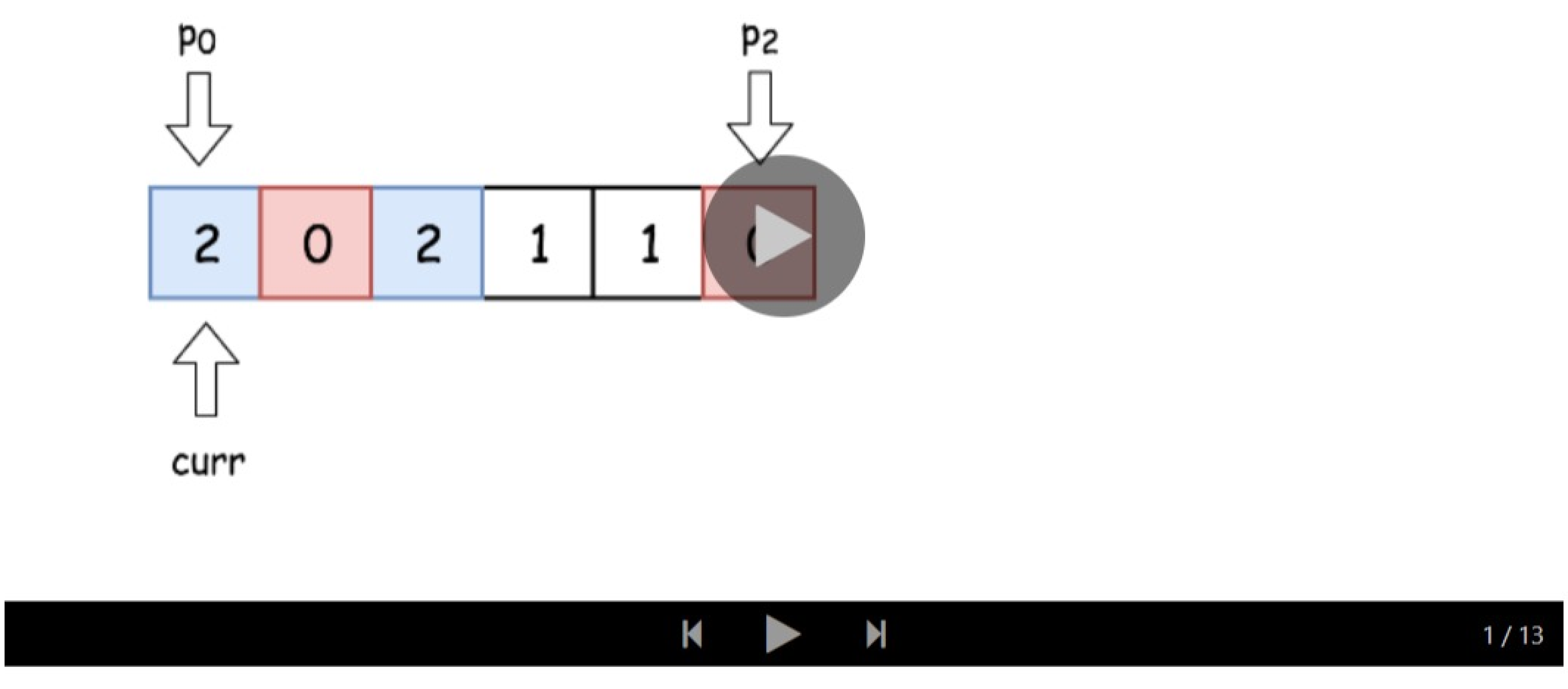


The idea of solution is to move `curr` pointer along the array, if `nums[curr] = 0` - swap it with `nums[p0]`, if `nums[curr] = 2` - swap it with `nums[p2]`.

Algorithm

- Initialise the rightmost boundary of zeros : `p0 = 0`. During the algorithm execution `nums[idx < p0] = 0`.
- Initialise the leftmost boundary of twos : `p2 = n - 1`. During the algorithm execution `nums[idx > p2] = 2`.
- Initialise the index of current element to consider : `curr = 0`.
- While `curr <= p2` :
  - If `nums[curr] = 0` : swap `curr`th and `p0`th elements and move both pointers to the right.
  - If `nums[curr] = 2` : swap `curr`th and `p2`th elements. Move pointer `p2` to the left.
  - If `nums[curr] = 1` : move pointer `curr` to the right.

Implementation



C++ Java Python Copy

```
1  class Solution:
2      def sortColors(self, nums: List[int]) -> None:
3          """
4          Dutch National Flag problem solution.
5          """
6          # for all idx < p0 : nums[idx < p0] = 0
7          # curr is an index of element under consideration
8          p0 = curr = 0
9          # for all idx > p2 : nums[idx > p2] = 2
10         p2 = len(nums) - 1
11
12         while curr <= p2:
13             if nums[curr] == 0:
14                 nums[p0], nums[curr] = nums[curr], nums[p0]
15                 p0 += 1
16                 curr += 1
17             elif nums[curr] == 2:
18                 nums[curr], nums[p2] = nums[p2], nums[curr]
19                 p2 -= 1
20             else:
21                 curr += 1
```

Complexity Analysis

- Time complexity : $\mathcal{O}(N)$ since it's one pass along the array of length N.
- Space complexity : $\mathcal{O}(1)$ since it's a constant space solution.

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MarufHassan 103 April 10, 2019 2:06 PM
It is actually a dual-pivot partitioning sub-routine of quick sort algorithm. Following is a well organized java code.

```
public void sortColors(int[] nums) {
```

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miladinho 223 February 14, 2020 11:40 AM Report
Shouldn't this be a Hard level problem?
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ats13 41 April 24, 2019 10:20 AM
@liaison and @andvary thanks for the analysis. Just one query, shouldn't we also increment the variable `curr` after line 19?
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henghaaya 69 April 13, 2019 4:17 AM
who have a idea if we extend this problem to k different colors
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oscardoudou 50 September 1, 2019 2:44 AM Report
For java solution, a little amendment: you don't need a new variable for tmp, since under either if branch you always have one value of the element you want to swap. Though the current code is more readable
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NikhilAgrawal07 119 July 20, 2019 11:40 PM
The hint of this question is to
see below code as low and high are inclusive boundaries of number 1
and (0,low-1) is contained with 0
and (high+1,nums.length-1) is contained with 2
and (low,high) is contained with 1
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tobe2019 77 April 11, 2019 6:32 PM Report
Thank you both for the problem and for this article!

It looks like there is a typo in the following sentence as "pointer **k**" is not mentioned anywhere else in the article:
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JAMESJJ78 204 April 10, 2019 7:43 PM
I'm going to try this out tonight and come back if I have any questions.
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krishgupta43 0 April 10, 2019 12:54 AM Report
void sortColors(vector<int>& n) {
int left=0,right=n.size()-1;
int i=0;
while(i<=right) {
if(n[i]==0)
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marcello834 28 June 18, 2020 8:53 PM Report
I counted all the colors in a new int[3] and refilled the original array. Still O(N). Glorious?
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