Solution: Boats to Save People

Let's solve the Boats to Save People problem using the Greedy pattern.

We'll cover the following

Statement

A big ship with numerous passengers is sinking, and there is a need to evacuate these people with the minimum number of life-saving boats. Each boat can carry, at most, two persons however, the weight of the people cannot exceed the carrying weight limit of the boat.

We are given an array, `people`, where `people[i]` is the weight of the i^{th} person, and an infinite number of boats, where each boat can carry a maximum weight, `limit`. Each boat carries, at most, two people at the same time. This is provided that the sum of the weight of these people is under or equal to the weight limit.

You need to return the minimum number of boats to carry all persons in the array.

Constraints:

- $1 \leq$ `people.length` $\leq 5 \times 10^3$
- $1 \leq$ `people[i]` $\leq$ `limit` $\leq 3 \times 10^3$

Solution

You may have already, brainstormed some approaches and have an idea of how to solve this problem. Let's explore some of these approaches and figure out which one to follow based on considerations such as time complexity and implementation constraints.

Naive approach

The naive approach is to use a nested loop. For each person, we can check all the remaining people to see if they can form a pair that fits into a boat. If we find a pair, we'll remove them from the array, increment the number of boats used, and move to the next person. If we can't find a pair for a person, we put them in a boat alone and increment the number of boats used. We repeat this process until all people are rescued.

The time complexity of this approach is $O(n^2)$, since we'll use the nested loop to make pairs.

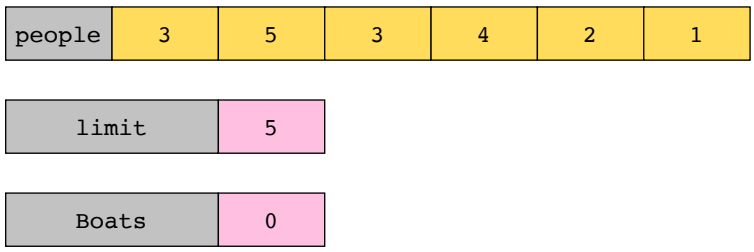
Optimized approach using the Greedy pattern

To solve the problem, we can use the greedy pattern and pair people with the lightest and heaviest people available, as long as their combined weight does not exceed the weight limit. If the combined weight exceeds

the limit, we can only send one person on that boat. This approach ensures that we use the minimum number of boats to rescue the people.

The steps to implement the approach above are given below:

1. Sort the `people` array in ascending order so that the lightest person is at the start of the array, and the heaviest person is at the end.
2. Initialize two pointers, `left` and `right`. The `left` pointer points to the lightest person at the start of the array, and the `right` pointer points to the heaviest person at the end of the array. Next, a variable, `boats`, is initialized to `0`, representing the number of boats used.
3. Iterate over the `people` array until the `left` pointer is greater than the `right` pointer. This means that all people have been rescued. Perform the following steps in each iteration of the loop
    - Check if both the lightest and heaviest persons can fit in one boat, i.e., `people[left] + people[right]` is less than or equal to `limit`. If they can fit, the `left` pointer is incremented and the `right` pointer is decremented.
    - If they cannot fit in one boat, the heaviest person is rescued alone, and the `right` pointer is decremented.
    - The `boats` variable is incremented by `1`, representing the number of boats used.
4. Return the minimum number of boats required to rescue all the people.



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Java

```java
import java.util.*;

class RescueBoats {

    public static int rescueBoats(int[] people, int limit) {
        // Sort the array of people in ascending order
        Arrays.sort(people);

        // Initialize pointers for the lightest and heaviest person
        int left = 0;
        int right = people.length - 1;

        // Initialize the number of boats needed
        int boats = 0;

        // Loop through the list of people until all people have been rescued
        while (left <= right) {
            // Check if the lightest and heaviest person can fit on the same boat
            if (people[left] + people[right] <= limit) {
                // If they can, move on to the next lightest person
```

```
21                 left++;
22             }
23             // Move on to the next heaviest person
24             right--;
25
26             // Add a boat for the current group of people
27             boats++;
28         }
```

Boats to Save People

Solution summary

- Sort the `people` array.
- Initialize two pointers—`left` at the start and `right` at the end of the array.
- Iterate over the `people` array while the `left` pointer is less than or equal to the `right` pointer.
    - Check if both the lightest and heaviest persons can fit in one boat. If so, increment the `left` pointer and decrement the `right` pointer.
    - Otherwise, rescue the heaviest person alone and decrement the `right` pointer.
    - Increment the `boats` after each rescue operation.

Time complexity

The time complexity for the solution is $O(n \log\ n)$, since sorting the `people` array takes $O(n \log\ n)$ time.

Space complexity

In Java, the sorting algorithm takes $O(n)$ space to sort the `people` array. Therefore, the space complexity of the solution above is $O(n)$.

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