LeetCamp

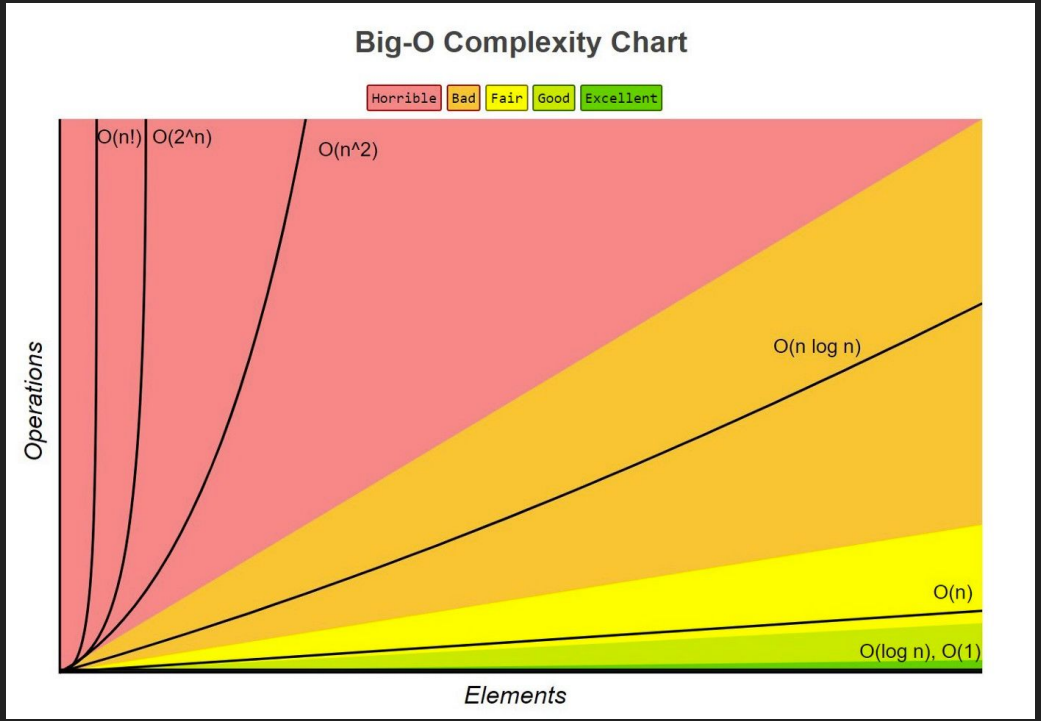
A project dedicated to DS&A

Agenda

1. Time Complexity Review
2. Binary Search
3. Q&A Time (hopefully)

Time Complexity (Speedrun)!

Time Complexity - Chart



https://www.bigocheatsheet.com/

```python
def example(nums):
    if len(nums) > 0:
        return nums[0]
    else:
        return -1
```

Time Complexity: O(1)
Space Complexity: O(1)

```python
def example(nums):
    for x in nums:
        print(x)

    for y in nums:
        print(y)
```

Time Complexity: O(N)
Space Complexity: O(1)

```python
def containsDuplicate(nums):
    """Determine if the list nums has duplicates."""
    for i in range(len(nums)):
        for j in range(len(nums)):
            if i != j:
                # if they are the same
                if nums[i] == nums[j]:
                    # because it does contain a duplicate
                    return True
    return False
```

Time Complexity: $O(n^2)$
Space Complexity: $O(1)$

aka: Hot Garbage

```python
def containsDuplicate(nums):
    """Determine if the list nums has duplicates."""
    prev = set()
    for x in nums:
        if x in prev:
            return True
        prev.add(x)
    return False
```

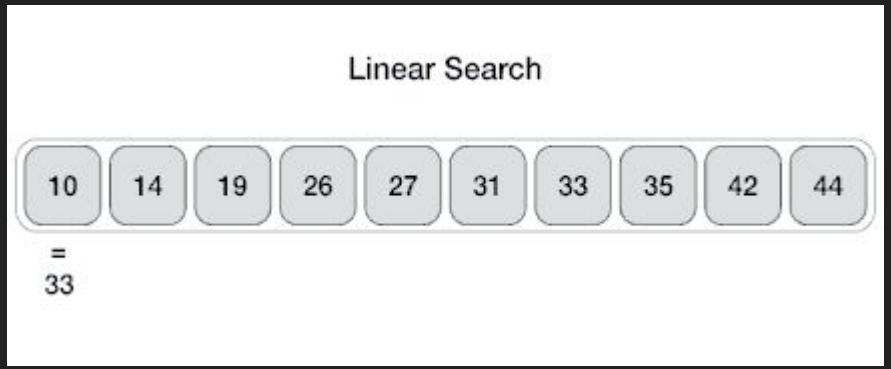
Time Complexity: O(n)
Space Complexity: O(n)

Binary Search

What is the simplest way to search?

- Linear search is when you check each item in the list to find a target

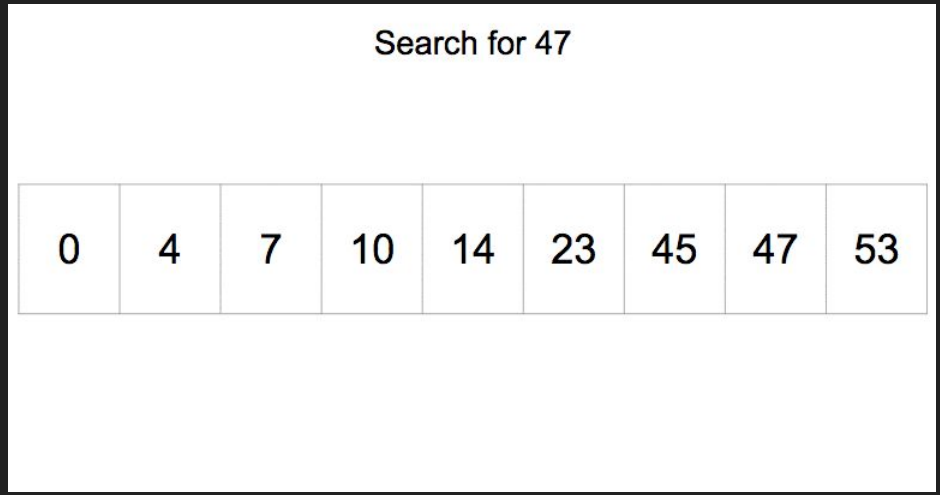
- **Time Complexity**: O(n) - each item checked
- **Space Complexity**: O(1) - nothing is stored

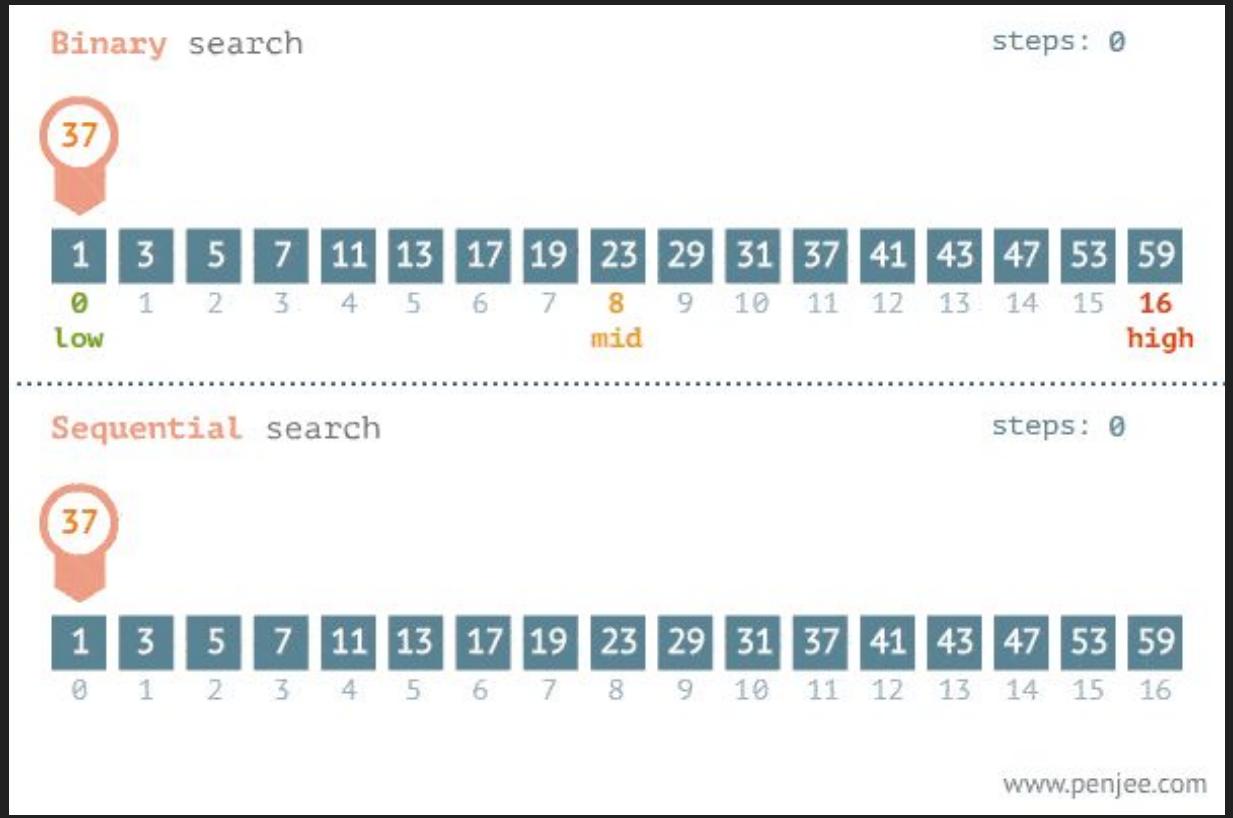


What is Binary Search?

- Asking yes or no questions that cut the problem in half
- Okay... What's the catch?
  - The elements **MUST BE SORTED!**

- **Time Complexity**: O(log n)
  - problem is cut in half with each question
- **Space Complexity**: O(1)
  - nothing is stored




Binary search
steps: 0
37
1 3 5 7 11 13 17 19 23 29 31 37 41 43 47 53 59
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
low
mid
high
Sequential search
steps: 0
37
1 3 5 7 11 13 17 19 23 29 31 37 41 43 47 53 59
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
www.penjee.com

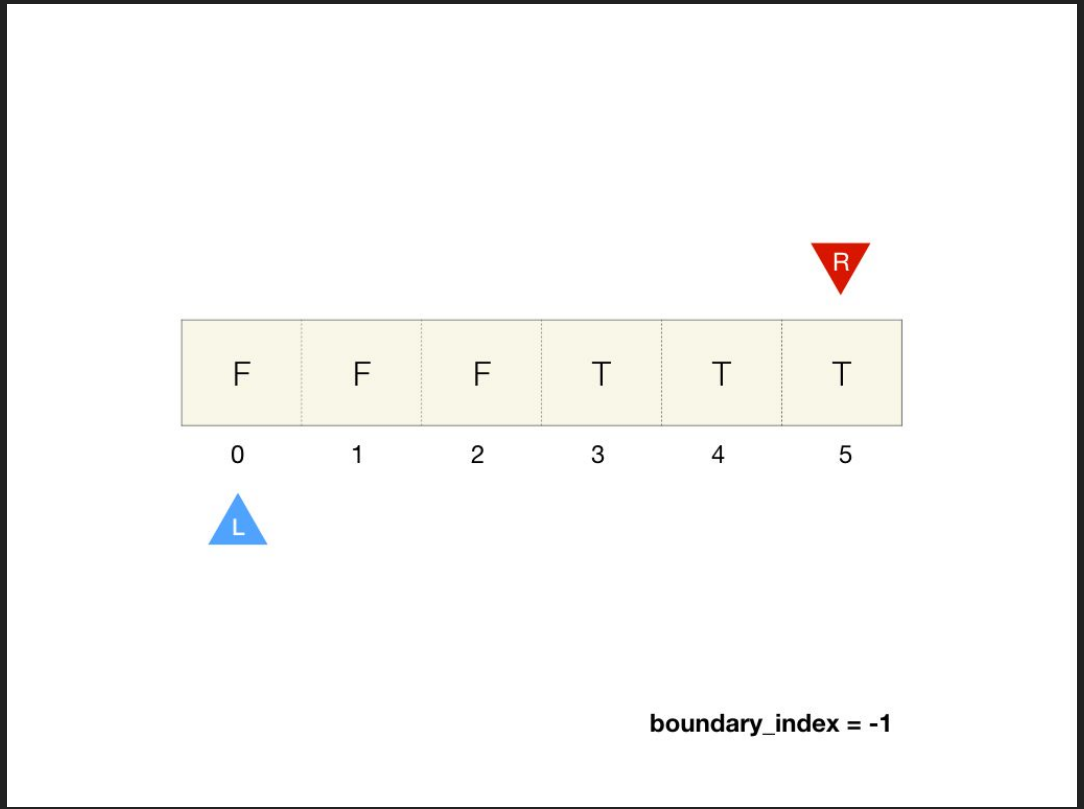
```python
def search(self, nums: List[int], target: int) -> int:
    left = 0
    right = len(nums) - 1

    while left <= right:

        mid = (left + right) // 2

        if nums[mid] == target:
            return mid
        elif nums[mid] > target:
            right = mid - 1
        else:
            left = mid + 1

    return -1
```

Time Complexity: O(log n)
Space Complexity: O(1)

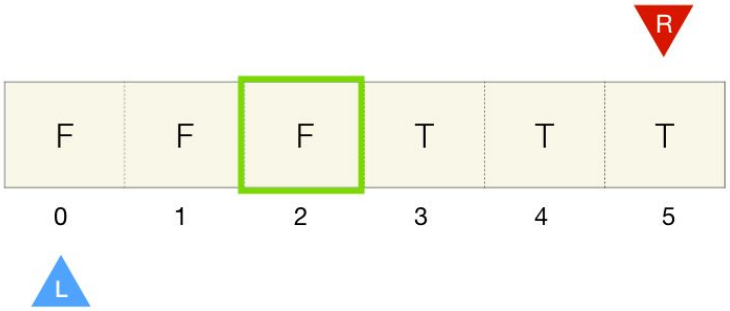
Finding Boundaries

- Binary search is not just for searching! (Wha....?)
- You can also binary search to efficiently determine how data changes after a certain index
- This index is known as the “boundary”
- Comes in handy when working with implicitly sorted arrays...

Finding Boundaries



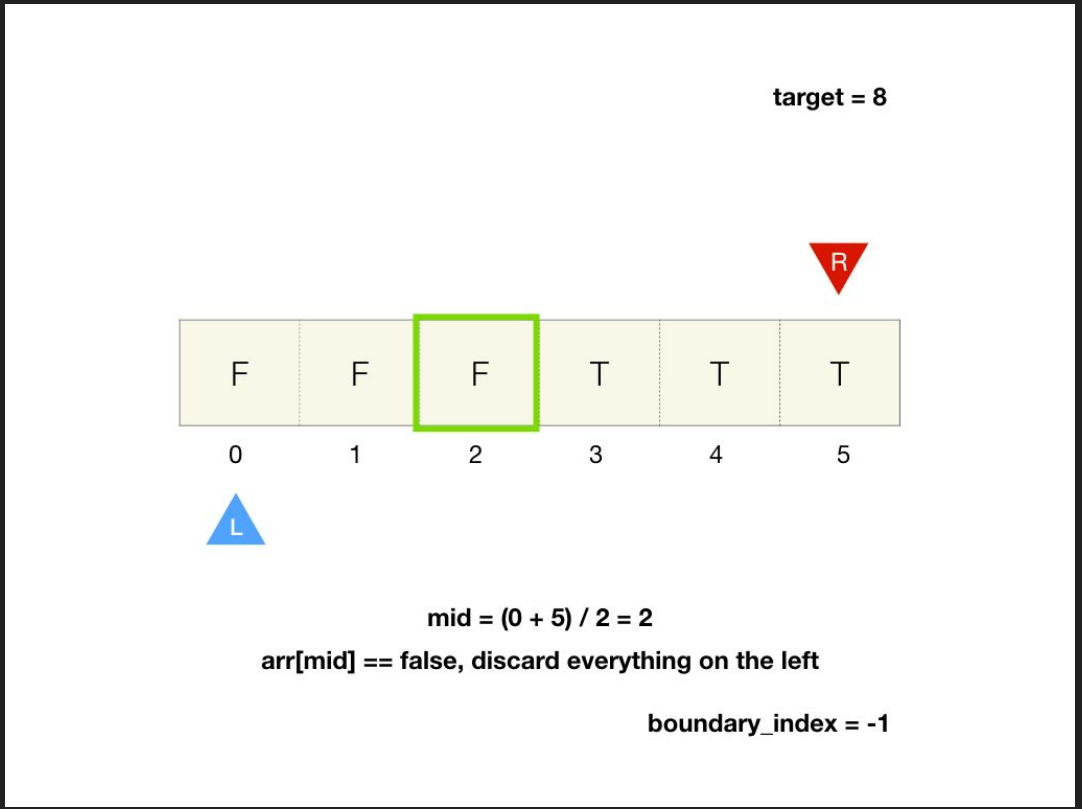
Finding Boundaries



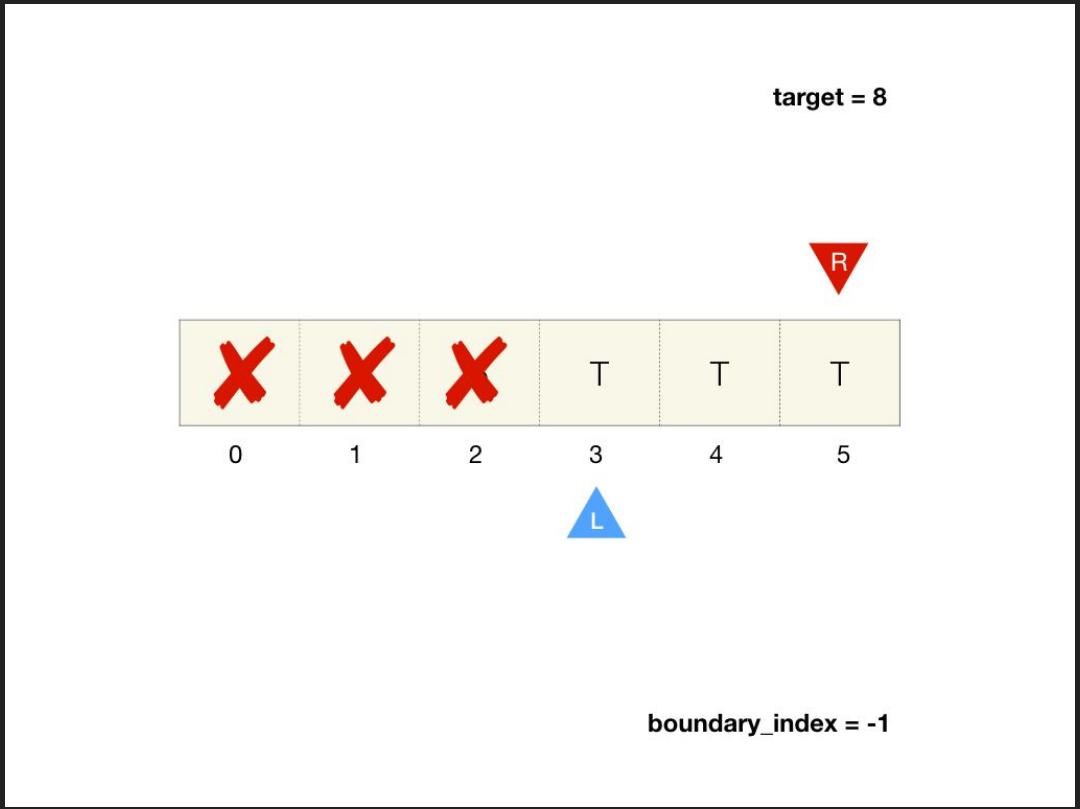
mid = (0 + 5) / 2 = 2

boundary_index = -1

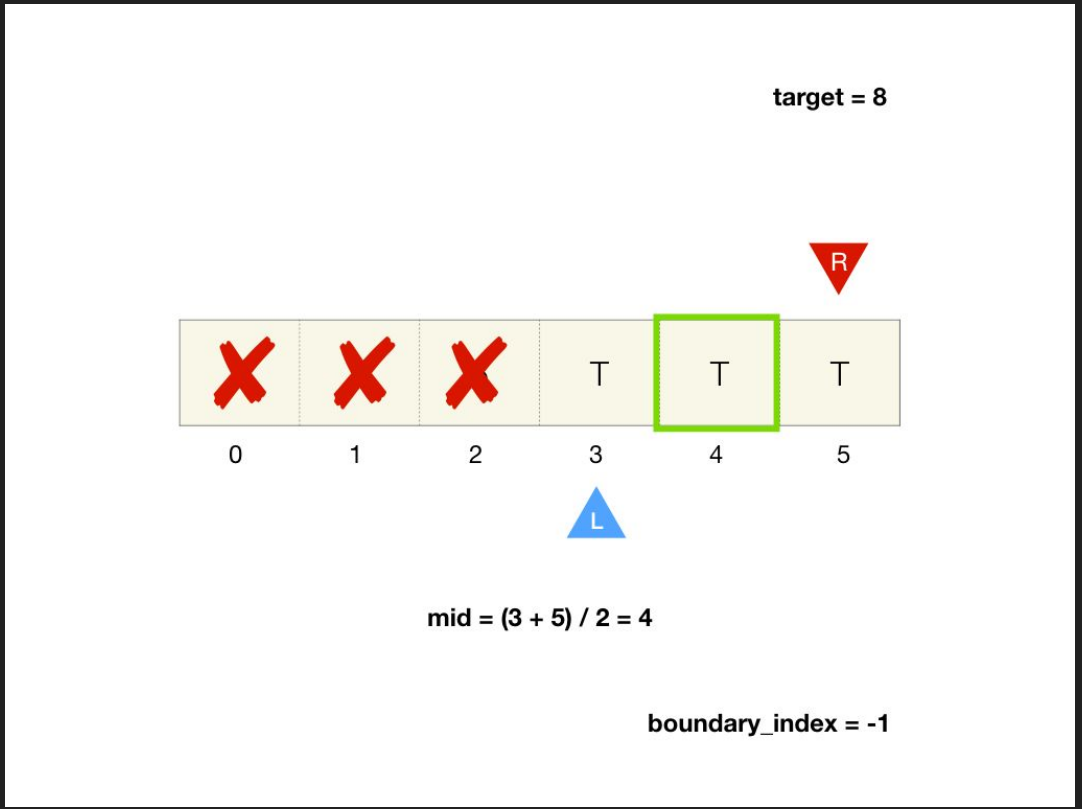
Finding Boundaries



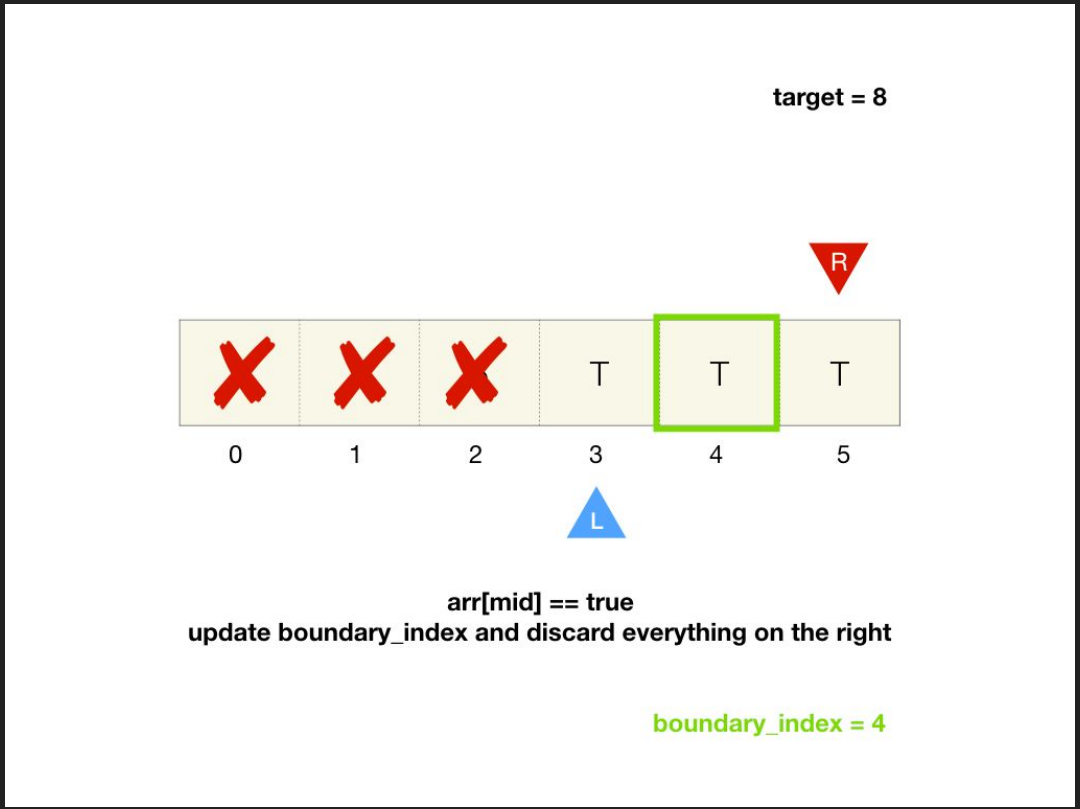
Finding Boundaries



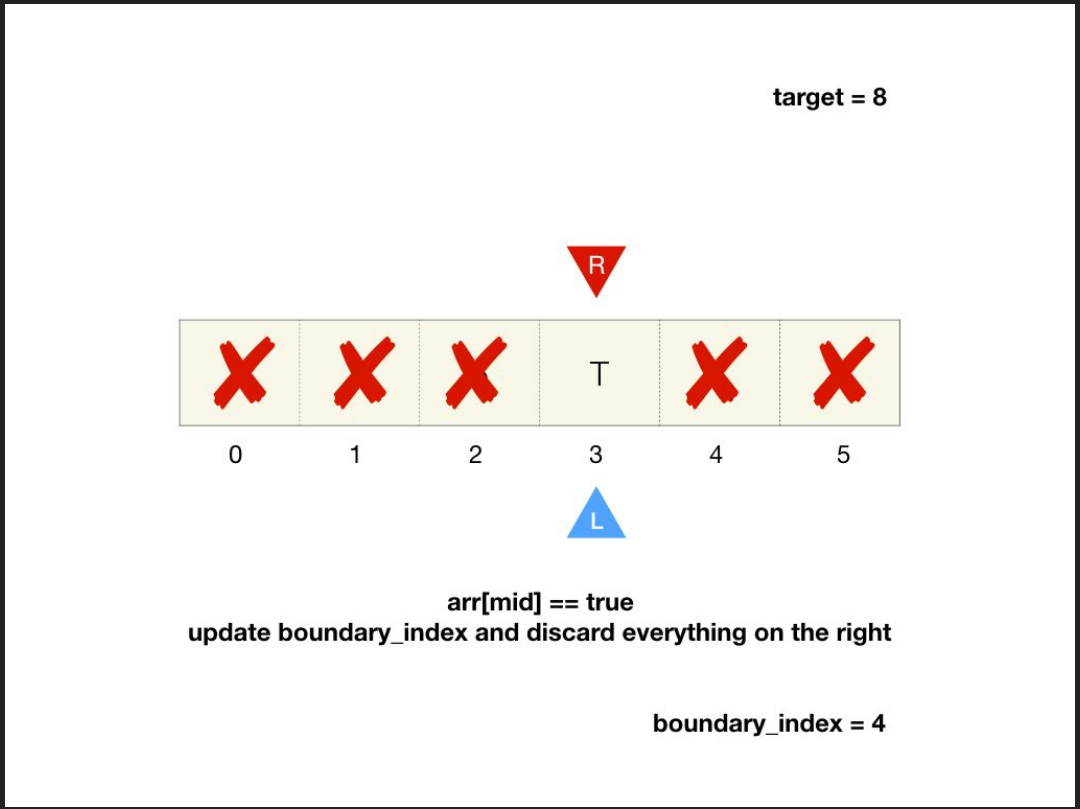
Finding Boundaries



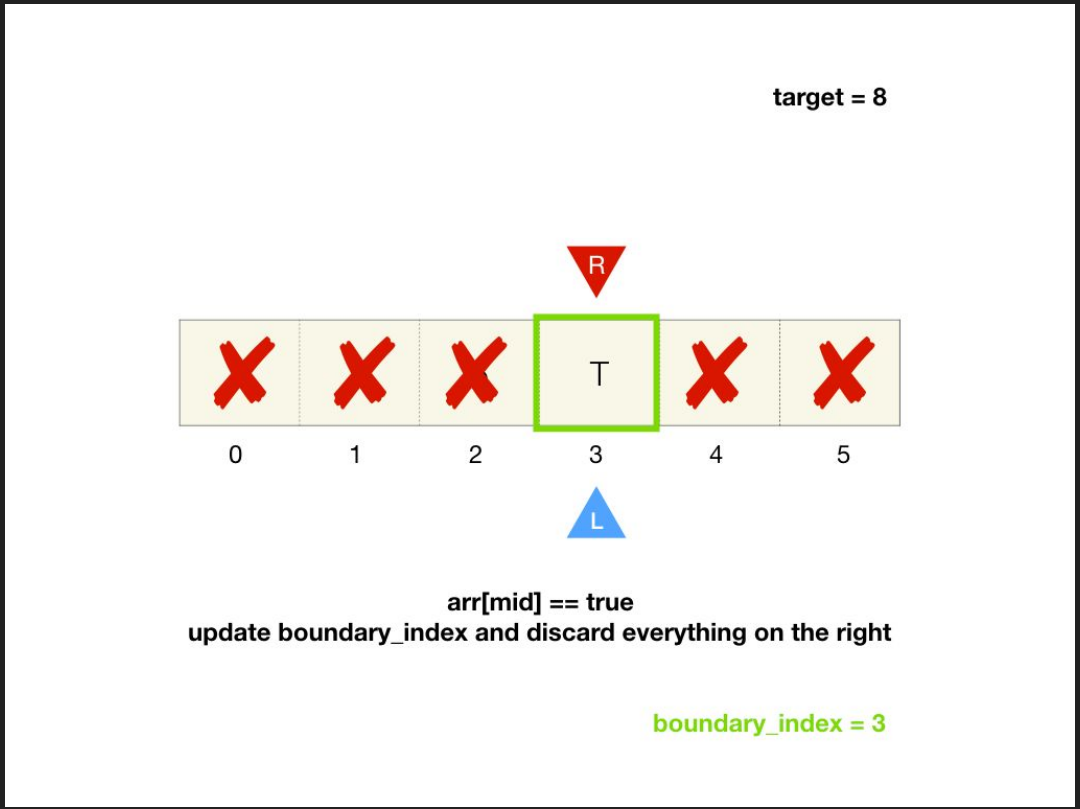
Finding Boundaries



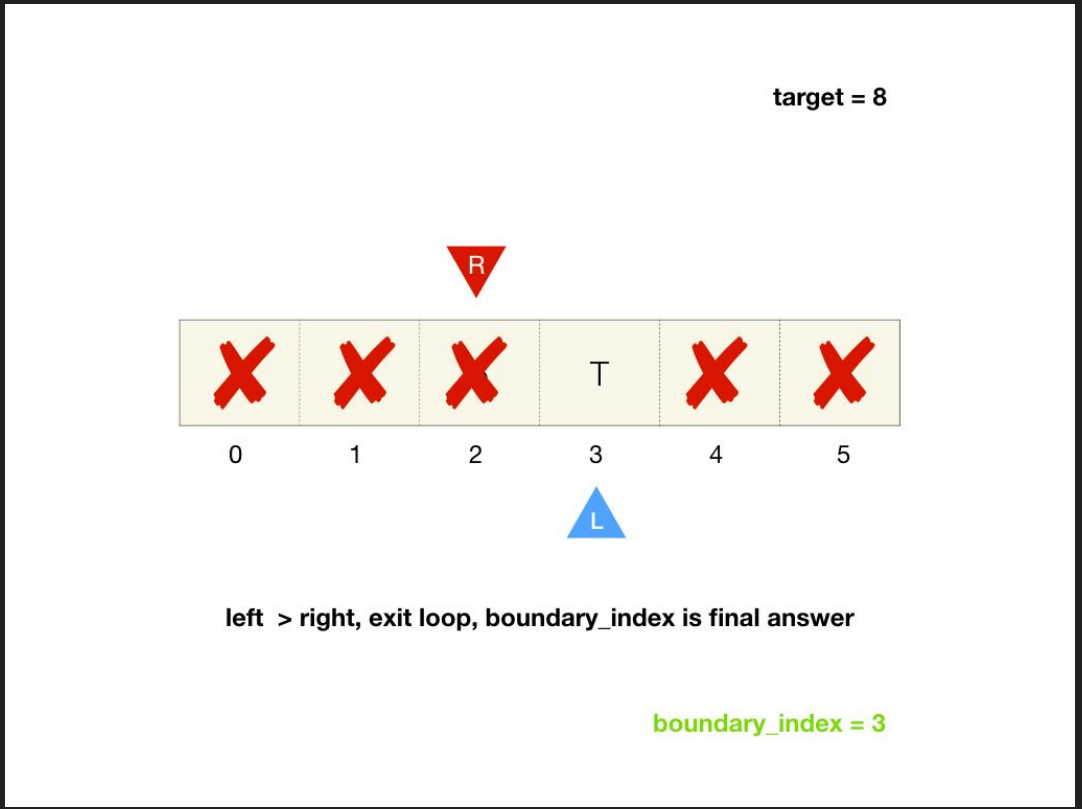
Finding Boundaries



Finding Boundaries



Finding Boundaries



“Find the Boundary” Template

- Here’s a good template to follow

```python
def find_boundary(arr):
    left, right = 0, len(arr) - 1
    boundary_index = -1

    while left <= right:

        mid = (left + right) // 2
        if arr[mid]:
            boundary_index = mid
            right = mid - 1

        else:
            left = mid + 1


    return boundary_index
```

- Time Complexity: O(log n)
- Space Complexity: O(1)

What Does "Implicitly Sorted" Mean?

- Basically a normal sorted array, but with a catch!
- The values in the array are sorted depending on:
  - A certain value in the array or....
  - A certain index in the array
- Normal sorted arrays are usually sorted in increasing / decreasing order
- Many MANY problems boil down to finding the boundary

- Example: Find the minimum in a sorted array that is pivoted:
  - For example, [10, 20, 30, 40, 50] becomes [30, 40, 50, 10, 20]
  - The list is not sorted, but there is a pattern that can be leveraged

Until next time...
Keep practicing

More Problems

To Start:

- https://leetcode.com/problems/binary-search/
- https://leetcode.com/problems/valid-perfect-square/
- https://leetcode.com/problems/sqrtx/
- https://leetcode.com/problems/find-smallest-letter-greater-than-target/

Medium:

- https://leetcode.com/problems/peak-index-in-a-mountain-array/
- https://leetcode.com/problems/capacity-to-ship-packages-within-d-days/
- https://leetcode.com/problems/two-sum-ii-input-array-is-sorted/

Hard:

- https://leetcode.com/problems/median-of-two-sorted-arrays/

Practice Problems

- https://neetcode.io/practice

- Try working on the
- Binary Search questions in the “NeetCode ALL” tab