

1 QuickCo

Malicious Mallory has been hired by a competitor to break into QuickCo, the world leader in sorting algorithms, and tamper with its Quicksort algorithms by making them as slow as possible. Mallory succeeded in unlocking the mainframe, but now she needs your help in slowing QuickCo's algorithms down to a halt!

For this question, assume that the Quicksort algorithm used has three steps.

1. Iterate through the array, to count how many elements are smaller than the pivot, larger than the pivot, and equal to the pivot.
2. Create 3 arrays for smaller, larger and equal elements of the correct size and then, in a second run through the array, place the appropriate elements in these arrays.
3. Finally, recurse on the smaller and larger arrays.

```
int[] data = { 1, 2, 3, 4, 5, 6, 7, 8, 9 };
```

- 1.1 Mallory decides to change the way QuickCo chooses a pivot for Quicksort.

Given the `int[] data` of size `n`, what choice of pivot would cause the worst-case runtime for Quicksort? Expand out the first few steps of the quicksort algorithms in such a case.

2 *Sorting Algorithms*

- 1.2 Mallory finds an algorithm which always selects the middle element but she is unable to gain write access to it. If the array has an even number of elements, the algorithm picks the element to the left. However, Mallory discovers a way to intercept the incoming data and rearrange it before the algorithm runs.

Given the `int[] data` of size `n`, rearrange the numbers such that the algorithm will run in its worst-case time. Expand out the first few steps of the quicksort algorithms in such a case.

- 1.3 Does the worst-case runtime of Quicksort depend on the array order, pivot choice, or both? Why?
- 1.4 If the worst-case runtime of Quicksort is $O(N^2)$ while the worst-case runtime of Mergesort is $O(N \log N)$, why do we ever use Quicksort?

2 Getting to Know You

- 2.1 Run MSD and LSD radix sort on the following DNA sequence such that the output is sorted in alphabetical order ($A < C < G < T$).

ACAG

CTAG

ACAA

TGAG

CCTC

GAGT

ACAG

CTAG

ACAA

TGAG

CCTC

GAGT

- 2.2 Performing Radix Sort seems to be a fast sorting algorithm. Why don't we always use it?

- 2.3 Why does Least-Significant Digit radix sort work?

3 More Asymptotics Potpourri

Algorithm	Best-case	Worst-case	Stable
Counting Sort			
LSD Radix Sort			
MSD Radix Sort			

4 Berkeley Bytes Buffet

You are the proud owner of Berkeley Bytes Buffet and business is good! You have a policy where children under 8 eat free and seniors eat 50 percent off. Since you're a savvy business owner, you keep the ages of all your customers.

- 4.1 For taxes, you must to submit a list of the ages of your customers in sorted order. Define `ageSort`, which takes an `int[]` array of all customers' ages and returns a sorted array. Assume customers are less than 150 years old.

[illegible]

4.2 Time passes and your restaurant is doing well. Unfortunately, our robot overlords advanced medicine to the point where humans are now immortal.

(a) How could we extend the algorithm to accept a list of any ages?

(b) When would we be able to use this type of sort?