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Lab W2D1

Q.N.1

```
Algorithm toySort (A, Start, Stop, ColorSet)
    if(ColorSet.size() == 1) return
    leftColorSet ⇐ first Half Of ColorSet
    RightColorSet ⇐ Second Half Of ColorSet
    i ⇐ Start
    j ⇐ Stop
    while (i <= j) do
        while(i < Stop & A[i].Color is in
                RightColorSet) i++
        while(i > Start & A[j]. Color is in
                LeftColorSet) j--
        if(i < j)
                Swap (A, i, j)
                i++
                j--
toySort (A, Start, i-1, LeftColorSet)
toySort (A, i, end, RightColorSet)
```

W2D1

Q.N.1 → Representing color in number

Suppose,

k = no. of colors

n = no of Toys

↳ Divide every time half

depth ↓ So depth is log k

width is n →

↳ look every element in the array

Time complexity is n log k

→ We donot need anything extra space so, that the algorithm is inplace Algorithm.

Space complexity of merge sort is O(n) because we need extra space to sort.

→ Merge sort is not inplace Algorithm.

Good self call & Bad self call

2

a) 1, 2 3 4 5 6 7 8 9

=> pivot => 5 ie: Good Pivot

1 2 3 4 9 6 7 8 5

i i j

1 2 3 4 5 6 7 8 9

Pivot = 4 Pivot = 9 ie: Bad Pivot

1 2 3 4 5 6 7 8 9

i j i i j

1 2 3 4 5 6 7 8 9

Pivot = 2 Pivot = 7. ie: Good Pivot

1 3 2 4 5 6 8 7 9

i i j i i

1 2 3 4 5 6 7 8 9

j i → i

1 2 3 4 5 6 7 8 9

Thus sorted

(6) {8, 7, 6, 5, 4, 3, 2, 1, 9}

⇒ Pivot = 8, 9, 4   ie: Good Pivot = 8

9 7 6 5 4 3 2 1 8
i j

1 7 6 5 4 3 2 9 8
i j i

~~1 2 6 5 4 3 7 9 8~~
i j

1 7 6 5 4 3 2 8 9

Pivot = 1, 2, 5   ie: Bad Pivot = 5

1 7 6 2 4 3 5 8 9
i i j

1 3 6 2 4 7 5 8 9
i j

1 3 4 2 6 7 5 8 9
ij i

1 3 4 2 5 7 6 8 9

Good Pivot = 1, 2, 3 ⇒ 3   ⇒ 7.

1 2 4 3 5 6 7 8 9
i i ji   ij i

1 2 3 4 5 6 7 8 9

Thus sorted

(c) { 9, 1, 8, 2, 7, 3, 6, 4, 5 }

⟹ pivot = 5, 9, 7 ⟹ 7. (Best)

9, 1, 8, 2, 5, 3, 6, 4, 7
i j

4 1 8 2 5 3 6 9 7
i → i j

4 1 6 2 5 3 8 9 7
i j, i

4 1 6 2 5 3 7 9 8

Bad Pivot ⟹ 4 and Pivot 9.

3 1 6 2 5 4 7 8 9
i → i j ← j ij

3 1 2 6 5 4 7 8 9
j ← ij

~~3 1 2 5 6 4 7 8 9~~

3 1 2 4 5 6 7 8 9

Good Pivot = 2.

3 1 2 4 5 6 7 8 9
i j

1 3 2 4 5 6 7 8 9
j i

1 2 3 4 5 6 7 8 9

Thus sorted.

(d) { 5, 1, 4, 2, 3, 9, 7, 6, 8 }

=> 5 1 4 2 3 9 7 6 8

pivot = { 3, 5, 8 } = 5 ie: Good Pivot

8 1 4 2 3 9 7 6 <u>5</u>

i j ← j

3 1 4 2 8 9 7 6 <u>5</u>

i j → i

3 1 4 2 <u>5</u> 9 7 6 <u>8</u>

Bad Pivot => P_1 = 4 and P_2 = 9

3 1 2 4 <u>5</u> 8 7 6 <u>9</u>

i → j → i   i → j → i

3 1 2 <u>4</u> <u>5</u> 8 7 6 <u>9</u>

Good Pivot = 2   Good Pivot = 7

3 1 <u>2</u> <u>4</u> <u>5</u> 8 6 <u>7</u> <u>9</u>

i j   i j

1 3 <u>2</u> <u>4</u> <u>5</u> 6 <u>8</u> <u>7</u> <u>9</u>

j i   j i

1 2 3 4 5 6 7 8 9

Thus sorted #

3 a) 1 2 3 4 5 6 7 8 9

$k = 5$

Bad pivot 1 2 3 4 5 6 7 8 9

9 2 3 4 5 6 7 8 1

i j

$\boxed{1}$ $\boxed{2\ 3\ 4\ 5\ 6\ 7\ 8\ 9}$

$L=0,\ E=1,\ G=8$

$k > |L| + |E|$

$5 > 0 + 1 \ = \ k = k - |L| - |E|$

$k = 4 \qquad = 5 - 0 - 1 = 4$

Good pivot 2 3 4 5 6 7 8 9

2 3 4 9 6 7 8 5

i i j

$k=4$ $\boxed{2\ 3\ 4}$ $\boxed{5}$ $\boxed{6\ 7\ 8\ 9}$

$L = 3 \quad E = 1 \quad G = 1$

$k > |L| \ \&\& \ k \leq |L| + |E|$

$4 > 3 \ \&\& \ 4 \leq 3 + 1$

Return $A[i] = 5$

$|L| + |E| = 4 = k = 4$

~~Fifth item in~~ E

Fifth item in E is 5

(5) ⇒ Here,

$k = 3$ and Array = {8,7,6,5,4,3,2,1,9}

8	7	6	5	4	3	2	1	9

Here,

Good Pivot = 5

8	7	6	9	4	3	2	1	5
i							j	
1	7	6	9	4	3	2	8	5
	i					j		
1	2	6	9	4	3	7	8	5
		i			j			
1	2	3	9	4	6	7	8	5
			i	j				
1	2	3	4	9	6	7	8	5
			j	i				
1	2	3	4	5	6	7	8	9

$L = 4$, $E = 1$, $G = 4$

$L < k \Rightarrow L = 4 > k = 3$

Recursive (L, 3)

1 2 3 4

Bad Pivot = 4

1	2	3	4
i		j →	i
1	2	3	4

$L = 3$, $E = 1$, $R = 0$

$L \leq K \Rightarrow 3$

$L = 3 \leq K = 3$

$L + E > K \Rightarrow 4 > 3$

Recursive (L, 3)

1 2 3

Good pivot = 2

1 3 $\underline{2}$

i i j

=> 1 $\underline{2}$ 3

thus

$L = 1$, $E = 1$, $R = 1$

then,

$L = 1 < K = 3$ But $L + E = 2 < 3$.

thus

$K = K - (L) - 1 (E)$

$= 3 - 1 - 1$

$= 1$

Recursive (G, 1)

Only one element thus value = 3 #

W12D1

3(c) 9 1 8 2 7 3 6 4 5

$k = 8$

Good pivot 9 1 8 2 7 3 6 4 5

9 1 8 2 7 3 6 4 5

i j

4 1 8 2 7 3 6 9 5

i → i j ← j

4 1 3 2 7 8 6 9 5

j i →

$\underbrace{4 \quad 1 \quad 3 \quad 2}_{L=4} \quad \underbrace{5}_{E=1} \quad \underbrace{8 \quad 6 \quad 9 \quad 7}_{G=4}$

$|L| = 4 < k = 8$

$|L| + |E| = 5 < k = 8$

$k = k - |L| - |E| = 8 - 4 - 1 = 3$

$k = 3$, pivot $= 6$

Bad pivot 8 6 9 7

8 7 9 6

i ← j

$L = 0 \quad \underbrace{6}_{E=1} \quad \underbrace{7 \quad 9 \quad 8}_{G=3}$

$|L| = 0 < k = 3$

$|L| + |E| = 1 < k = 3$

$k = k - |L| - |E| = 3 - 1 - 0 = 2$

$k = 2$

3(c) $k = 2$

7 9 8

7 9 8

7 8 9

$|L| = 1 < k = 2$

$|L| + |E| \geq k$

$\cancel{k = k - |L| - |E|}$

$\cancel{= 2 - 1}$

Eigth item in E is 8

(d) ⇒ Here,

$k = 5$

and array is $\{5, 1, 4, 2, 3, 9, 7, 6, 8\}$

5 1 4 2 3 9 7 6 8

Here,

Good Pivot = 5

8 1 4 2 3 9 7 6 5

i j ← j

3 1 4 2 8 9 7 6 5

i → j → i

3 1 4 2 5 9 7 6 8

$L = 4$, $E = 1$, $G = 4$

and $L < K$ ie: $L = 4 < k = 5$

thus

$\cancel{K = k =} |L| + |E| = 4 + 1 = 5$

thus

$K = |L| + |E|$

$= 5$

thus value = 5

W2D1

4) Width

$S(x)$ — n

$S(a)$ $\quad$ $S(b)$ — $\frac{2}{3}n$

$S(c)$ $S(d)$ $\quad$ $S(e)$ $S(f)$ — $\left(\frac{2}{3}\right)^2 n$

$\vdots$

1

$\log_{3/2} n$

$$n, \left(\frac{2}{3}\right)n, \left(\frac{2}{3}\right)^2 n, \left(\frac{2}{3}\right)^3 n \ldots\ldots 1$$

$$1 = \left(\frac{2}{3}\right)^k n$$

$$n = \left(\frac{2}{3}\right)^k$$

$$\log_{3/2}(n) = k$$

right $= \log_{3/2}(n)$

Which is $O(\log n)$

At each level of recursion tree total processing time is $O(n)$

$\therefore$ Total running time in the good case is $O(n \log n)$