for $i = 0$ to m: ← $m+1$

for $j = 0$ to Count[i]: ← $0, 1, 2, \vdots, m$] n

$m+1+n = O(m+n)$

$O(2n+m)$

O_1 O_2 1_1 1_2

key	0	0	6	4	5	3	1	2	1	2
value	E_2						Data$_1$		Data$_2$	

		Data$_1$	Data$_2$						
0	0	1	1	2	2	3	4	5	6

O_1 ? O_2 1_1 1_2

O_2 ? O_1

stable sort

z_1 z_2 Data

Values	0	0	6	4	5	3	1	2	1	2
idx	0	1	2	3	4	5	6	7	8	9

0... 6

items	0	1	2	3	4	5	6	idx
count	2	2	2	1	1	1	1	

C

idx	0	1	2	3	4	5	6
	2	3	5	7	8	9	10

n

idx	0	1	2	3	4	5	6	7	8	9
Result				1	2	2				

z_1 z_2

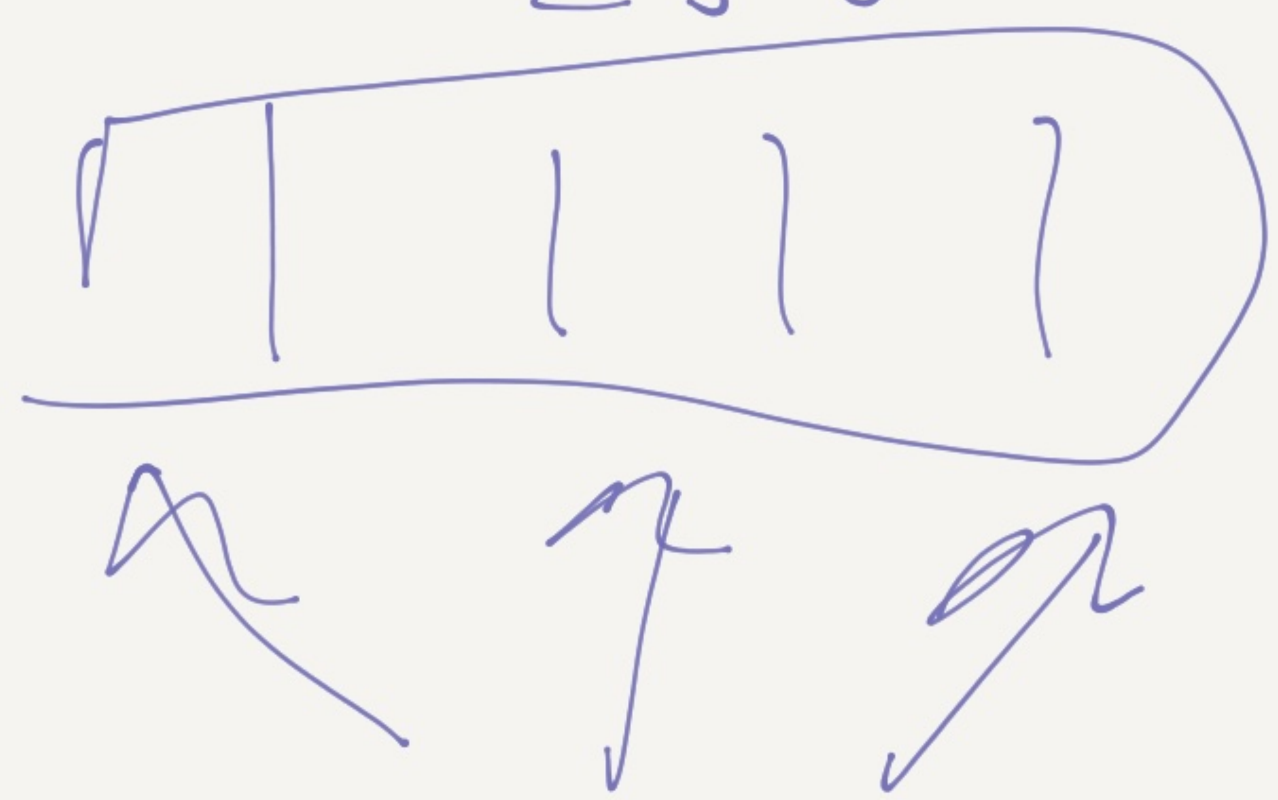
0 ... 255

256

$O(n)$

$\Omega(n)$

$\Theta(n)$



$a_i \,?\, a_j$

$\le$ $>$

$O(n \log n)$

Подсчетом

Кормен, гл.8

Седжвик, гл.10

Кнут

n, $a_0, a_1, \dots, a_{n-1}$

$\forall i \in [0; n-1] : 0 \le a_i \le M$

$a_i \in \mathbb{N}$

$\boxed{M+1}$

$\boxed{M \sim n} \Rightarrow O(n)$

0..M 6

0	1	2	3	4	5	6
2	2	2	1	1	1	1

0 0 6 4 5 3 1 2 1 2

$n + M + n$ $\quad O(2n + M)$ 3

$O(n)$ $\frac{3n}{4}$

0 0 1 1 2 2 3 4 5 6


Data
Result
Indices

0 0 6 5 3 4 1 2 1 2

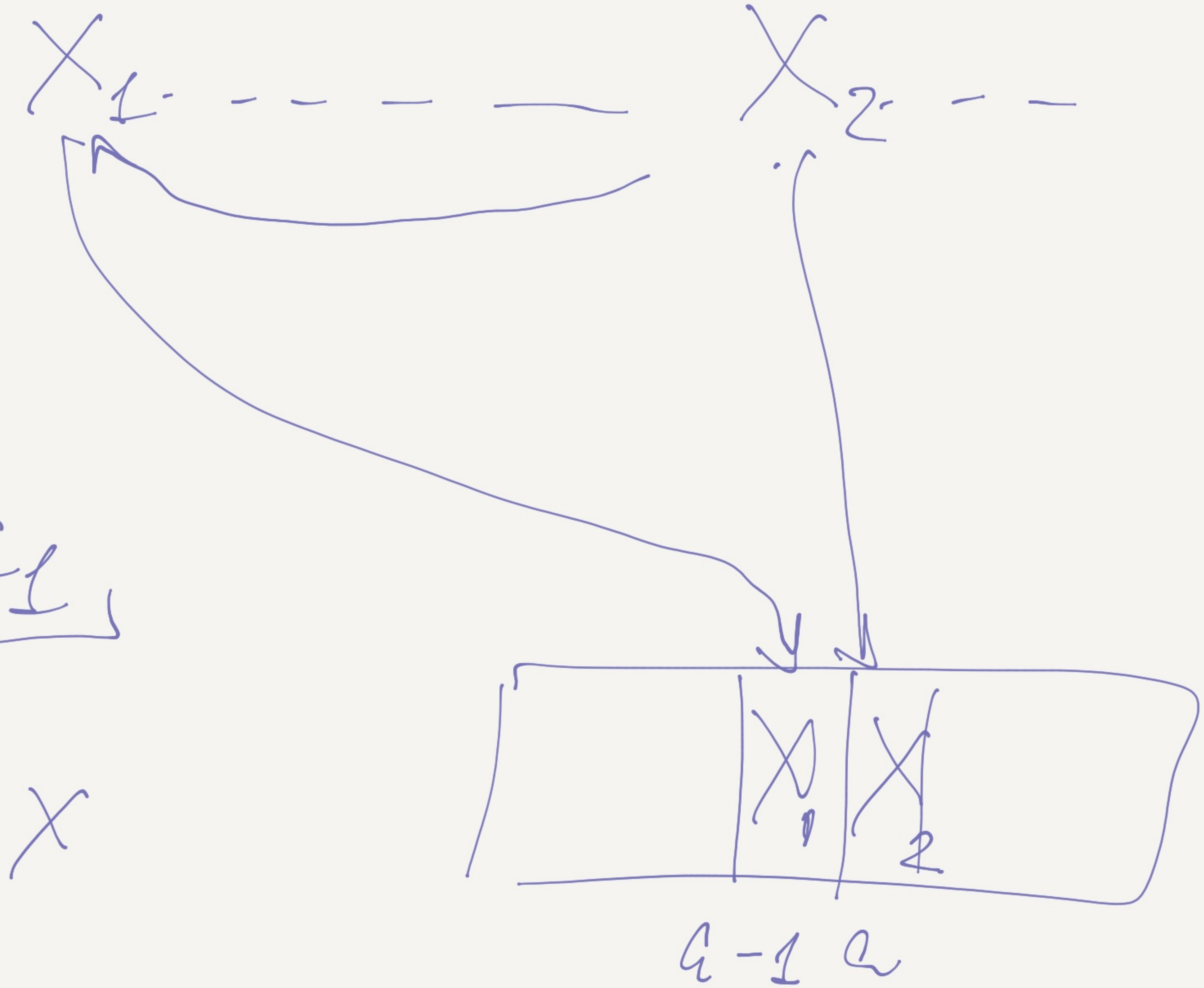
0	1	2	3	4	5	6
2	2	2	1	1	1	1

0	1	2	3	4	5	6
↓	↓	↓	↓	↓	↓	↓
2	4	6	7	8	9	10

←

0	1	2	3	4	5	6
↓	↓	↓	↓	↓	↓	↓
0	2	4	6	7	8	9

Count



$$Count[x] = \underbrace{\cancel{a}}_{a-1}$$

$$Result[a] = x$$

```
Counting Sort(Data, M):
    Count[0 ... M] = {0}
I   for i = 0 to Data.size() - 1:
        Count[Data[i]] += 1
II  for i = 1 to M:
        Count[i] += Count[i-1]
    for i = Data.size()-1 to 0:
        Result[Count[Data[i]] - 1] = Data[i]
        Count[Data[i]] -= 1
    return Result
```

0	1	2	...
2	2	2	

0	1	2	3	...
2	4	6	7	

Поразрядная
Radix Sort
0 … 9

$N = 10^5$

$M = 10^{18}$

$\cancel{M \gg N}$

N

$M = 10$

57
228
47
1
9

057
228
047
001
009

001
057
047
228
009

001
009
228
047
057

057
047
001
009
228

001
009
228
047
057

001
047
057
228
009

001
009
047
057
228

1
9
47
57
228

$n \to d$

For $i = 0$ to $d-1$: ~~10~~ b

$\underline{\text{Counting Sort}}(n, i)$ // не наша

номер разряда

$d \cdot O(n) \to O(d \cdot n) \to O(n)$

0...255

n

$\overbrace{\begin{matrix} 01 \ldots\ldots 10 \\ 11 \ldots\ldots 00 \\ 00 \ldots\ldots 11 \end{matrix}}^{b\ \text{бит}}$

R R R R бит

int_{32}

$\underbrace{8\ 8\ 8\ 8}_{32}$

4 255

n — количество — в штуках

b — длина числа — в битах

R — длина разряда — в битах

$O(n+m)$

$d = \frac{b}{R}$

$O(d \cdot n)$

$$\boxed{O\left(\frac{\boxed{b}}{R}\left(\boxed{n} + 2^{R}\right)\right)}$$

$2^R - 1$

$0 \ldots 2^R - 1$

$\boxed{b < \log_2 n} \Rightarrow \underline{R = b}$

$$\frac{b}{R}(n + 2^R) = \frac{b}{b}(n + 2^b) = n + 2^b < n + 2^{\log n} =$$

$$= 2n$$

$b \geq \log_2 n \Rightarrow \boxed{\underline{R} = \log_2 n}$

$$\frac{b}{R}(n + 2^R) = \frac{b}{\log_2 n}\left(n + 2^{\log_2 n}\right) =$$

$$= \frac{2bn}{\log n}$$

1
1
1
1
⋮
2
2
⋮
3
⋮
4
0
⋮
7

$\underbrace{2^{20}}$

0 7

3

000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

$b = 3$
$n = 2^{20}$

$b = 3 < 20 = \log_2 n$

CountingSort$(n, 7)$

$\underbrace{\ }\ \underbrace{\quad\quad}_{m}\ \underbrace{\quad\quad}_{e}$

$$\vdash A \ \ldots \ B \longrightarrow \underbrace{0 \ldots B \in A}$$

$A, B \geq 0$

$a_0 \in A$, $a_1 \in A$. ..., $a_{n-1} \in A$

$\vdash A$ $\vdash A$ $\vdash A$