

# Insertion Sort



10 → 35 →

~~10~~ ←

5    10    35

5    10    20    35

15    20    35    45

25    35    45

Worst case

45 35 25 20 15 10 5

35 45

35 45

25

25 35

45

20

(N-1)

$$1 + 2 + 3 + \dots + (N-1)$$

Worst

$O(N^2)$  compares

$O(N^2)$  Moves

Best Case

5 10 15 20 25 35 45

Compare

1 + 1 + 1 + ...  
N-1 times

$O(N)$  compares

$\phi$  moves

Best

~~LL~~

35 → 10 → 5 → 20 → 15 → 45 → 25

→

10 → 35

5 → 10 → 35

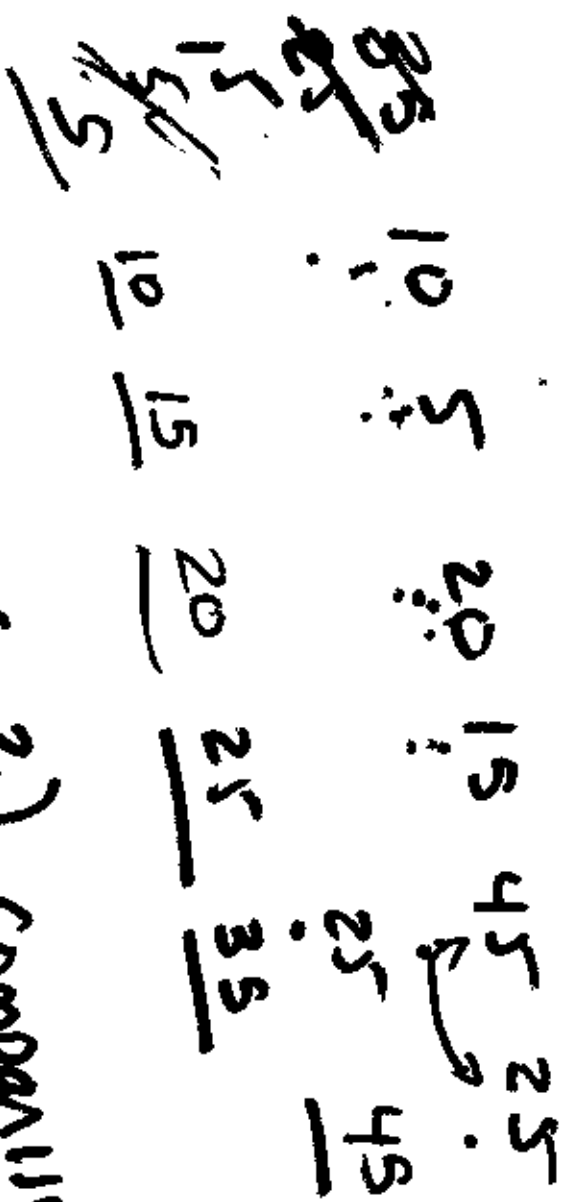
10 → 20 → 35

Compare  $O(N) \rightarrow O(N^2)$

Moves  $\phi$   ~~$O(N)$~~   ~~$O(N^2)$~~

$O(N)$

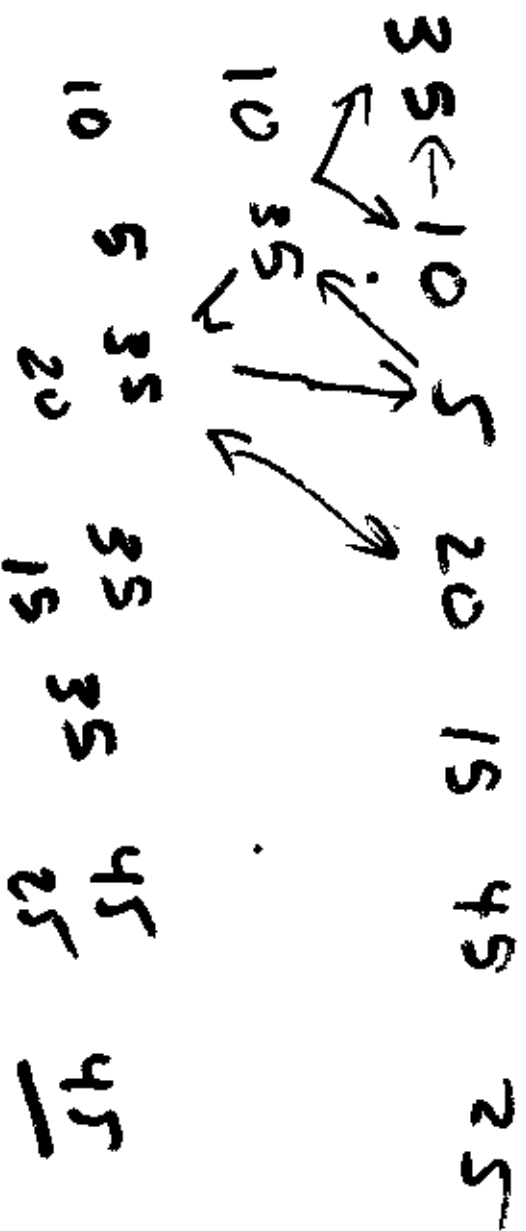
# Selection Sort



$O(N^2)$  Comparisons  
All of time

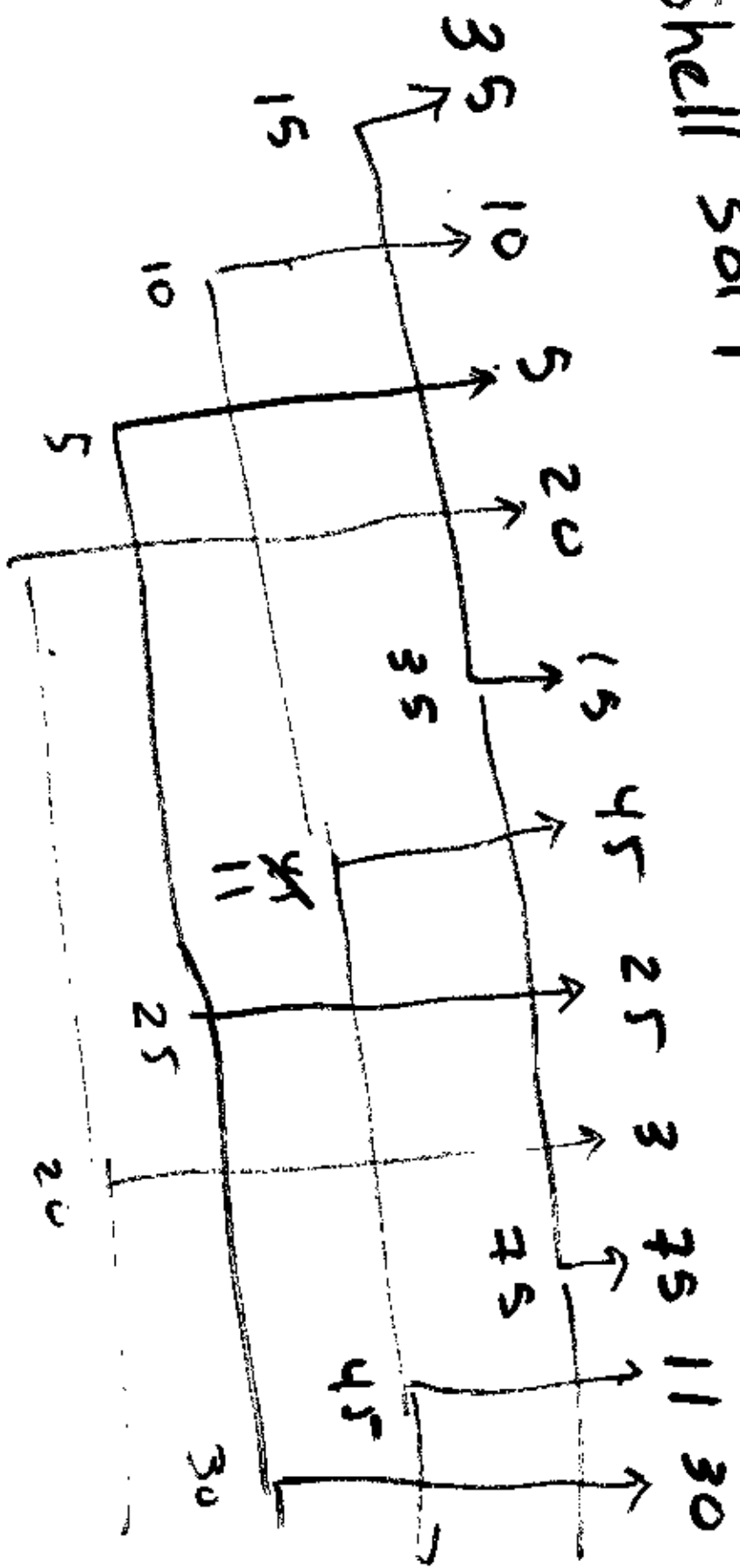
$\phi \rightarrow O(N)$   
from

# Bubble/Exchange



$\phi \rightarrow O(N)$  #exchanges  
 $\downarrow$   
 $O(N^2)$   
 compare  $\phi(N) \rightarrow O(N^2)$

# Shell sort



15	10	5	3	35	11	25	20	75	45	30
10	15	10	5	35	11	25	20	75	45	30
5	10	15	11	35	25	25	30	75	45	75
3	5	10	15	35	25	30	35	75	45	75

<u>A</u>	<u>D</u>	<u>I</u>	<u>L</u>	<u>M</u>	<u>P</u>	<u>S</u>
ATL	DEN DEN	JFK	LAX LAX	MSF MSF	PDX	SFO SFO SFO SFO

$\phi$  compares  
 $O(N * \text{Key length})$  moves



# RADIIY

DEN JFK LAX SFO PDX ~~STP~~ STE  
DFW MSP SLC ATL

C  
STC  
SLC  
K  
JFK L  
ATL

N  
DEN

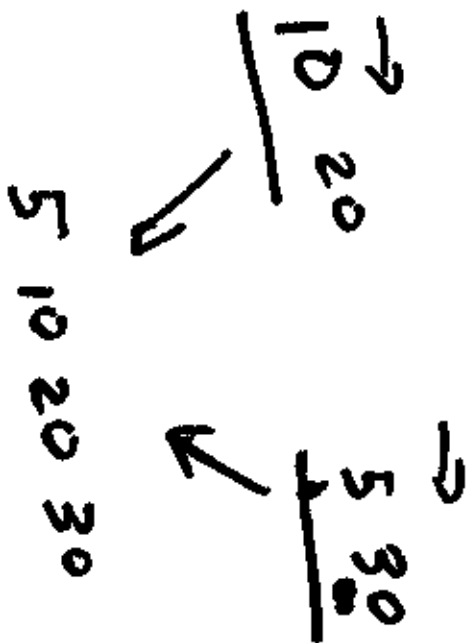
O P W  
SFO }  
DEN }  
LAX  
PDX

MSP

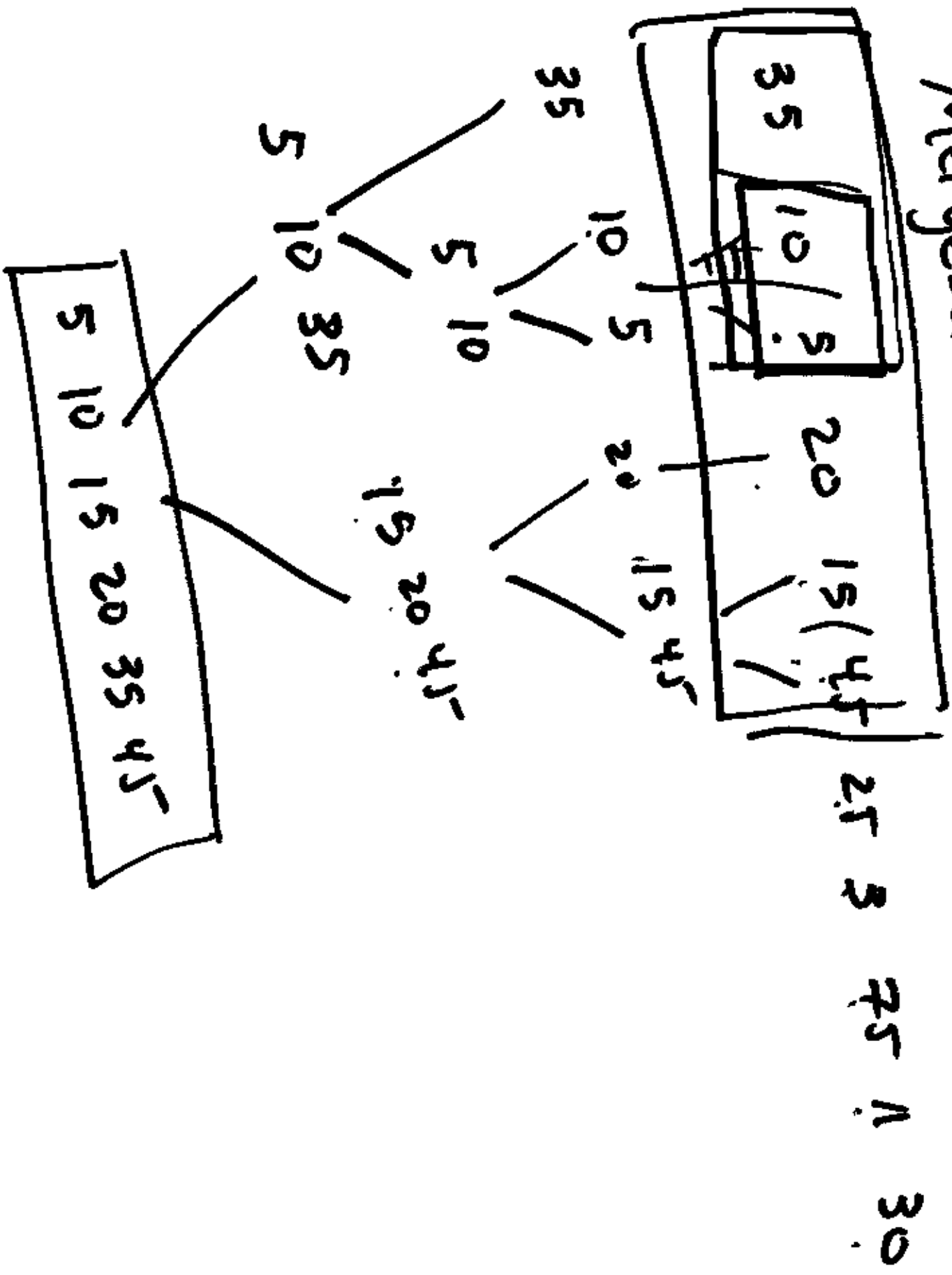
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A D E  
LAX } DEN  
PDX }  
F  
JFK  
SFO  
DFW  
L  
SLC  
I  
MSP  
T  
STC  
ATL

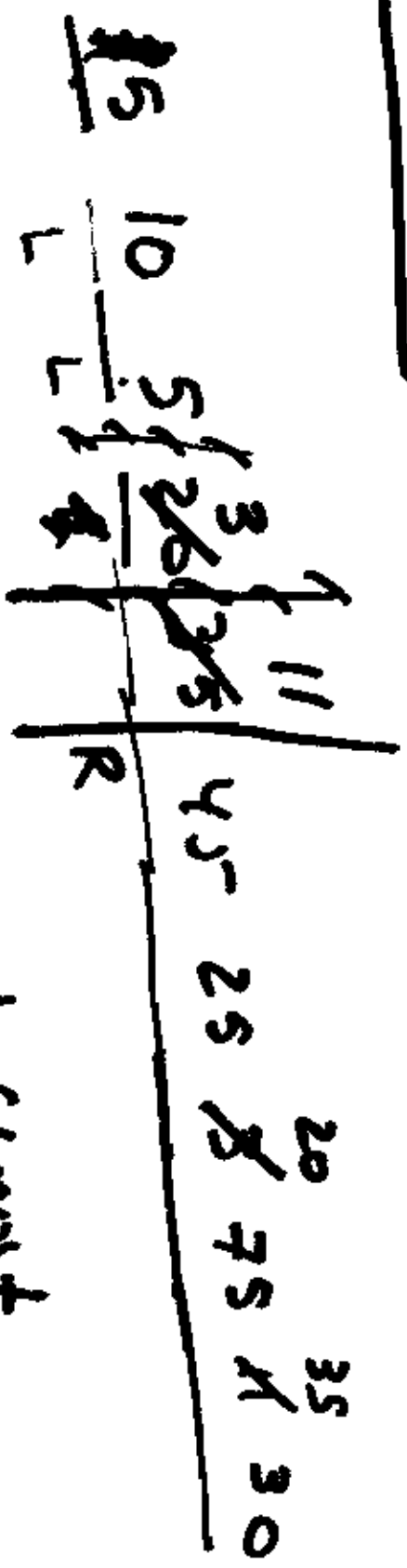
# Merge Sort



# Merge Sort



# Quick Sort



- Swap 3 with the leftmost item in the Right partition
  - Swap P. Value with the Rightmost item in the Left partition
- 11 10 5 3 15 4 5 2 5 20 7 5 1 30

5 3 10 11 8 10

L R

3 5

11 10 11

15

20

25 45 75 35 30

R

35 45 75 25 30

25 { 30 | 45 75

R

30 25 35

45 75