



Optimization of vehicle routing problem using artificial bee colony algorithm

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Problem Statement

Capacitated vehicle routing problem(CVRP) is a combinatorial optimization problem which states as follows:

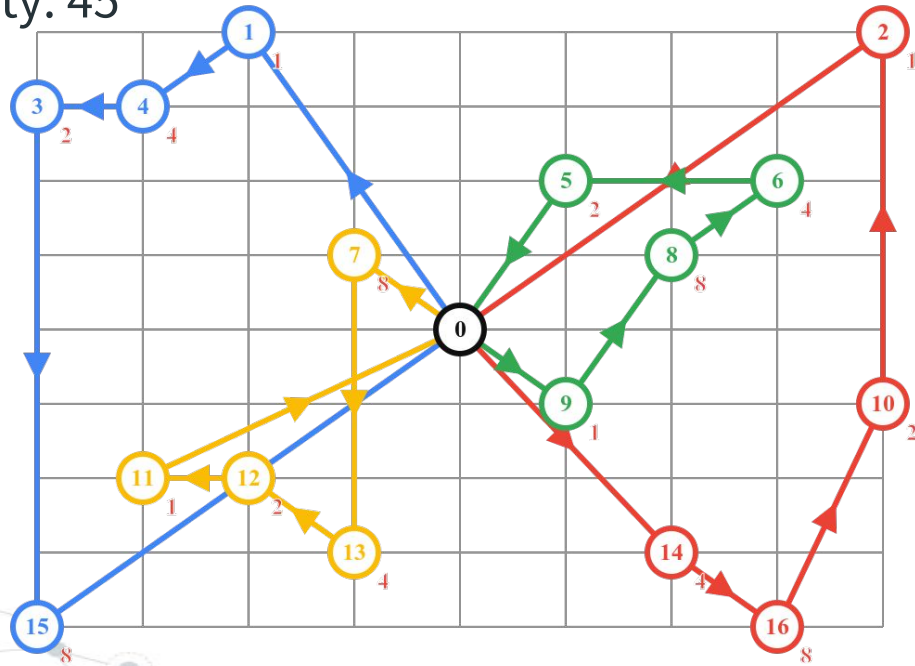
“ Find the optimal delivery routes for a set of vehicles to supply the set of customers with given demands minimizing the total cost of all the routes.”



Example

Number of vehicles: 4

Vehicle Capacity: 45



Computation complexity

<i>Problem Size (Number of Nodes)</i>	<i>Approximate Solution Time</i>
10	3 milli-seconds
20	77 years
25	490 million years
30	8.4×10^{15} years
50	9.6×10^{47} years


Dataset

- The dataset I selected is from branchandcut.org
- It has datasets for Traveling salesman CVRP etc.
- It has ~ 107 files for CVRP problem

```
2 NAME : A-n32-k5
3 COMMENT : (Augerat et al, No of trucks: 5, Optimal value: 784)
4 TYPE : CVRP
5 DIMENSION : 32
6 EDGE_WEIGHT_TYPE : EUC_2D
7 CAPACITY : 100
8 NODE_COORD_SECTION
9 1 82 76
10 2 96 44
11 3 50 5
12 4 49 8
13 DEMAND_SECTION
14 1 0
15 2 19
16 3 21
17 4 6
18 DEPOT_SECTION
19 1
20 -1
21 EOF
```

Algorithm

A decorative network graph in the top right corner, featuring nodes of varying sizes (some solid, some hollow) connected by thin lines, representing a complex network structure.

1. Given a set of customers find all the ways in which the customers can be served given a set of vehicles. (Subset finder)
 2. Out of all the the ways found what is the best way (Traveling salesman)
- 
- A decorative network graph in the bottom left corner, similar to the one in the top right, showing a cluster of nodes and connecting lines.

Recurrence relation

$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$

Problem statement

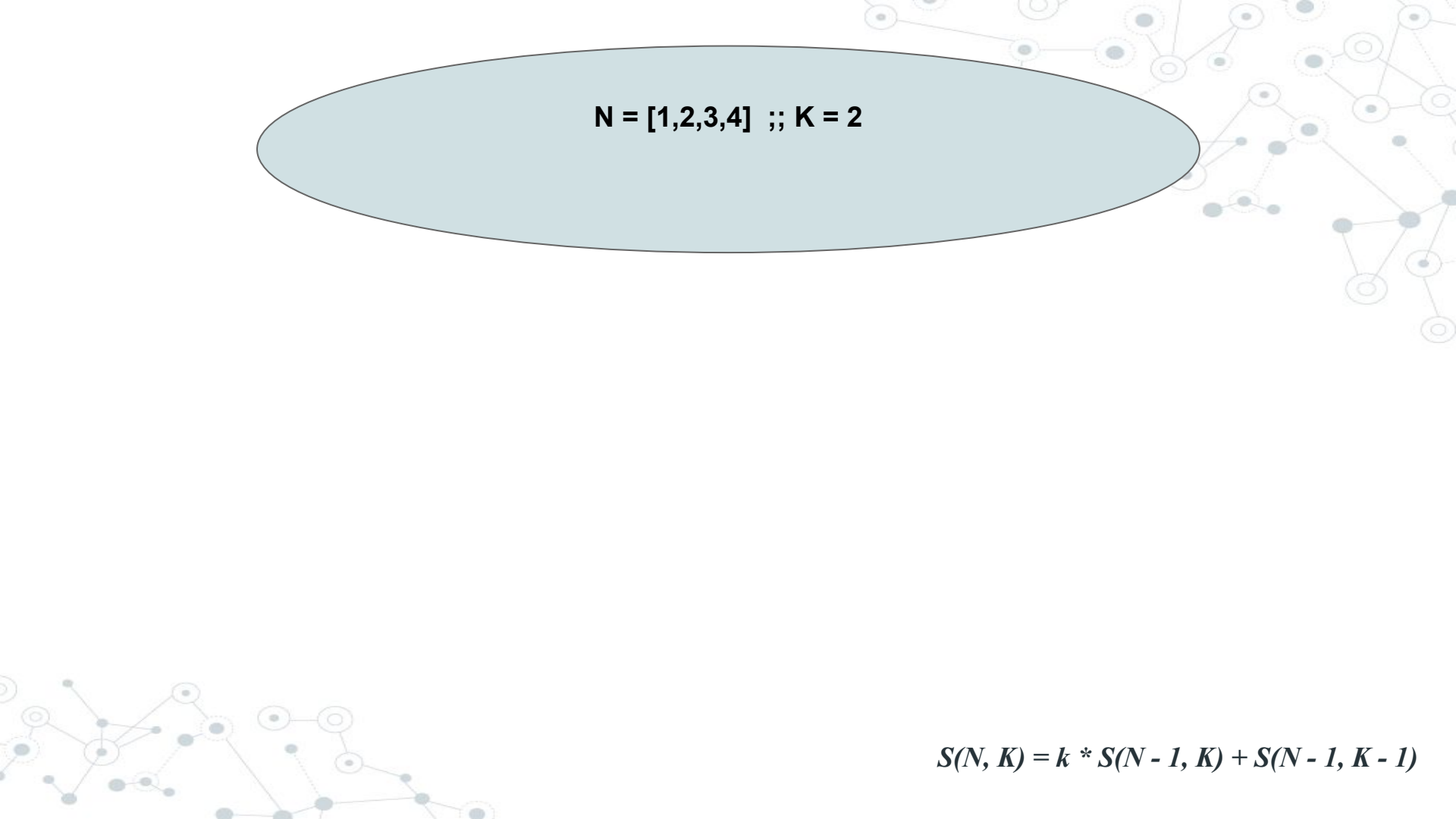
There are 4 customers numbered from 1 to 4 and let depot be 0.

Distance Matrix

	0	1	2	3	4
0	0	2	31	4	12
1	3	0	12	4	5
2	5	9	0	10	11
3	3	2	12	0	4
4	13	7	10	8	0

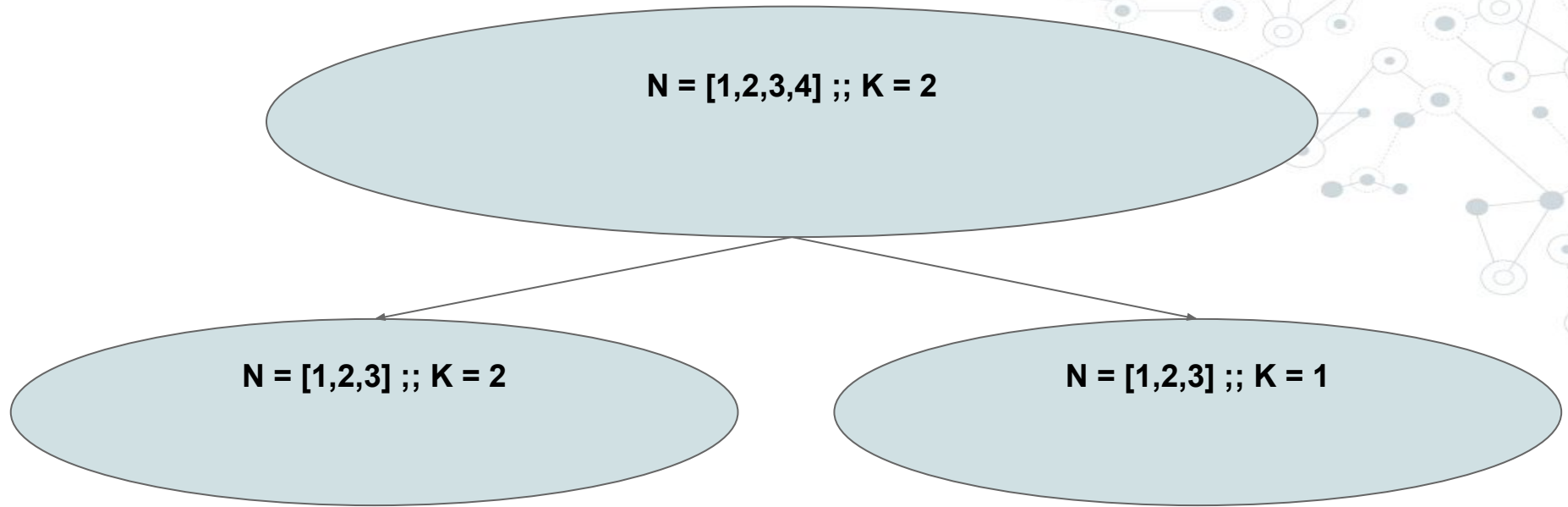
Demand

0	-1
1	12
2	8
3	20
4	9

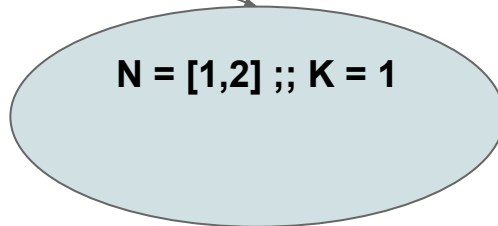
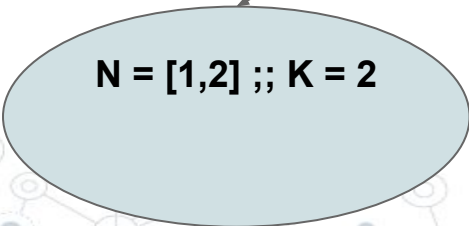
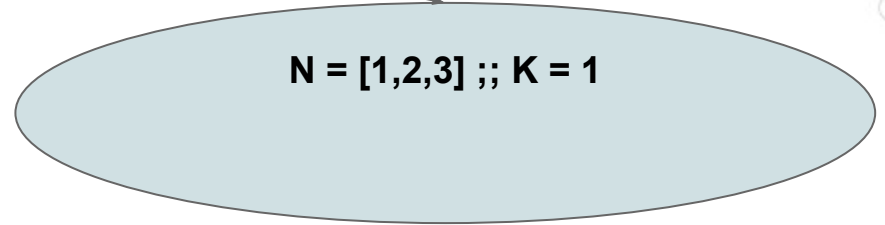
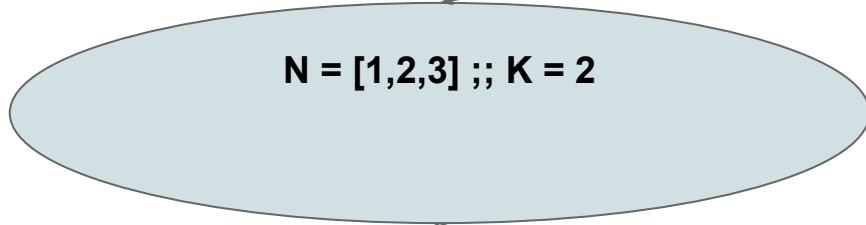
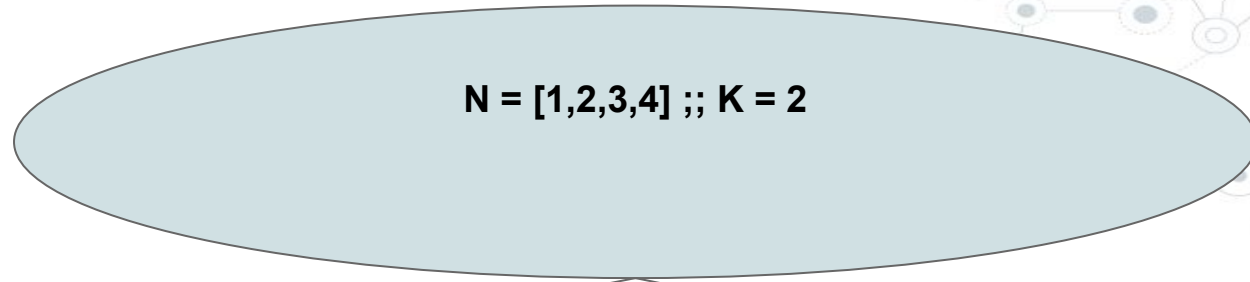


$N = [1,2,3,4] \quad ; ; K = 2$

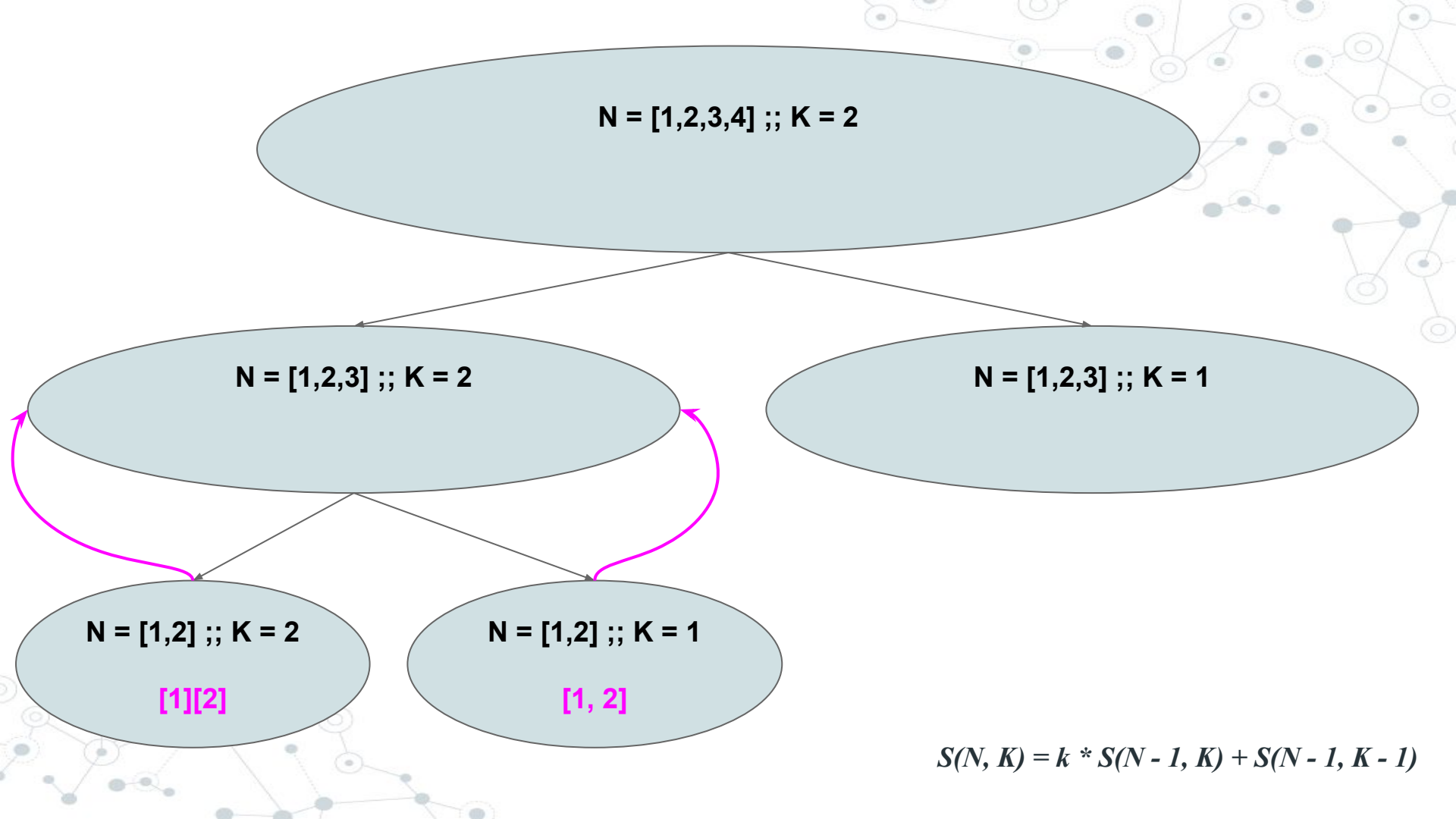
$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$



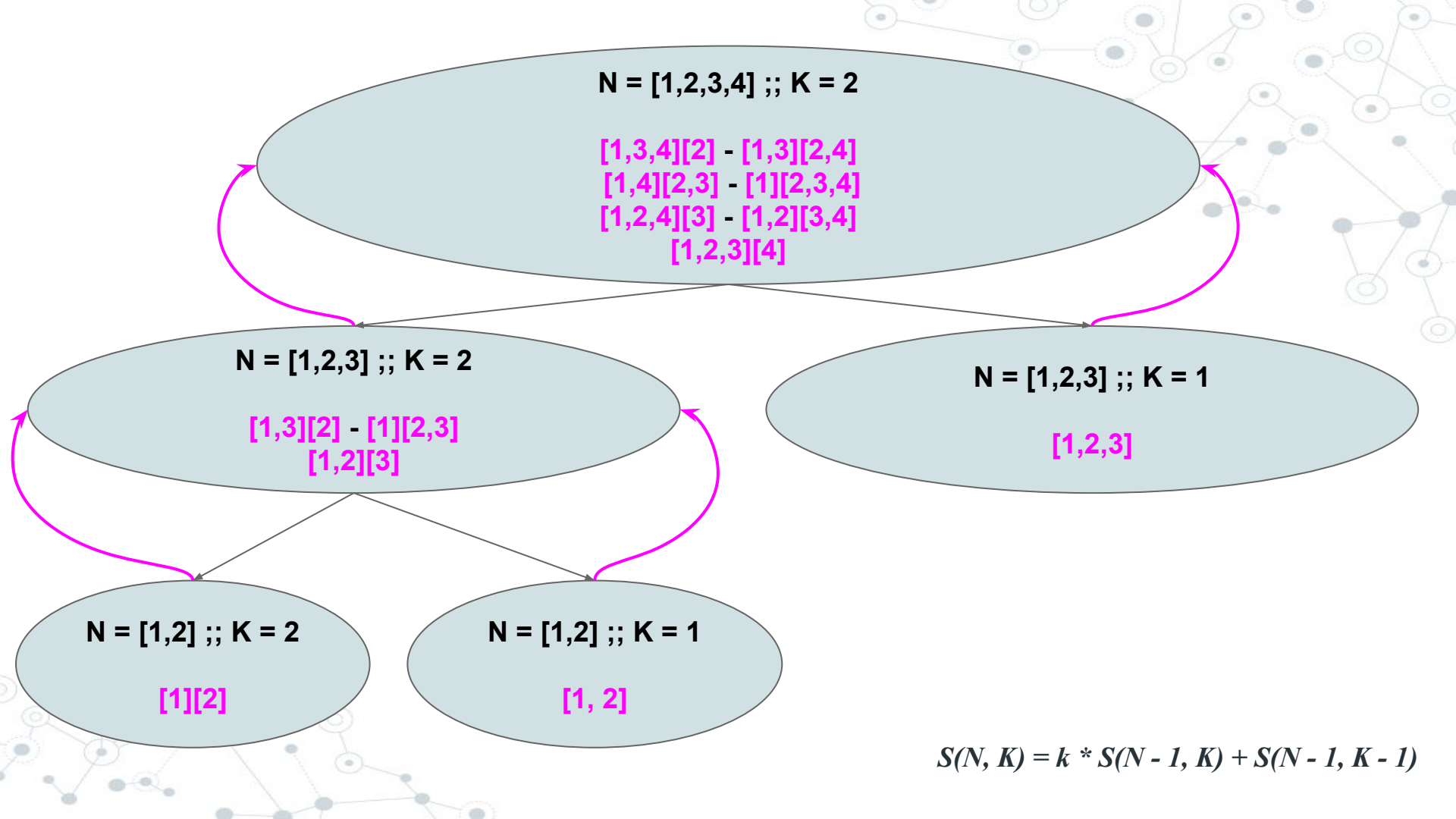
$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$

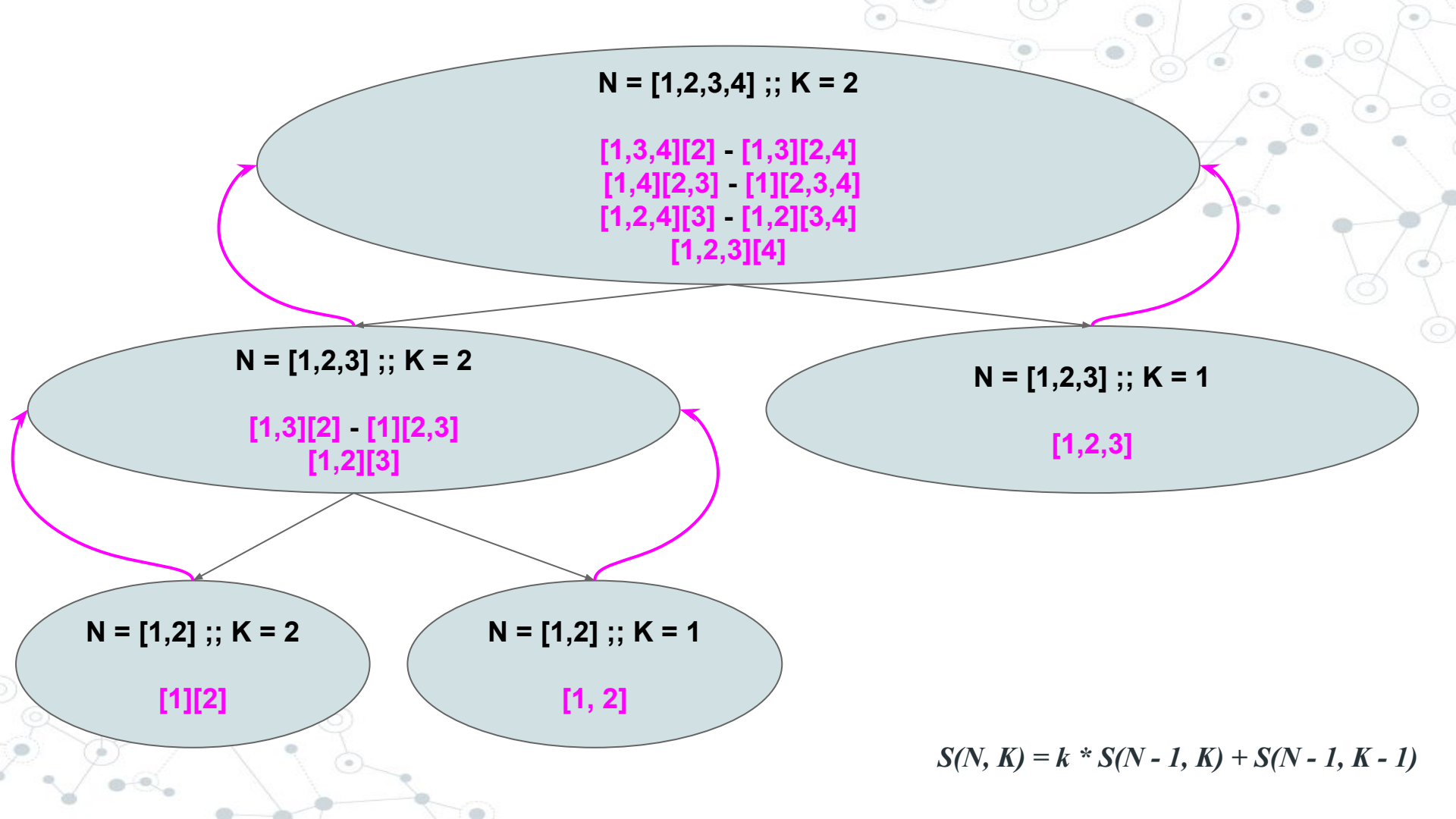


$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$



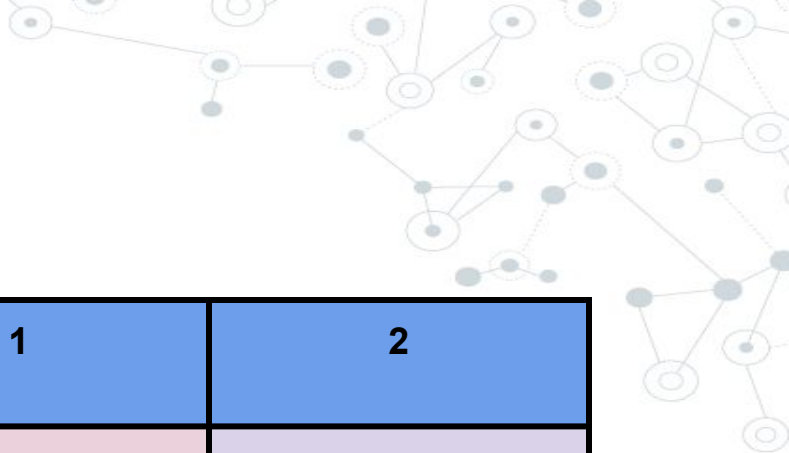
$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$








Subset finder (Dynamic Programming)



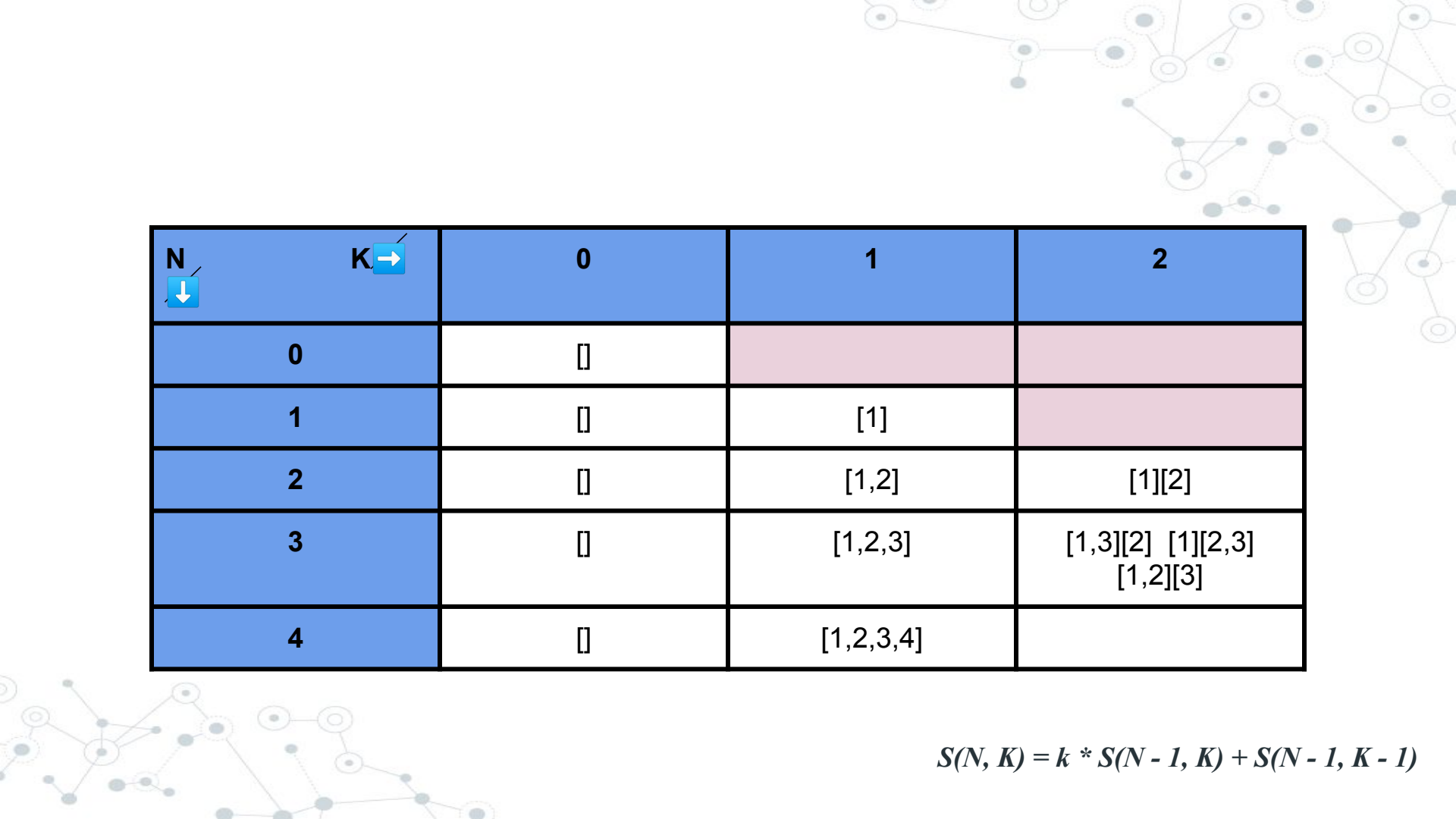
<div> <div>N</div> <div>↓</div> </div> <div> <div>K</div> <div>→</div> </div>	0	1	2
0			
1			
2			
3			
4			

$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$


BaseCases

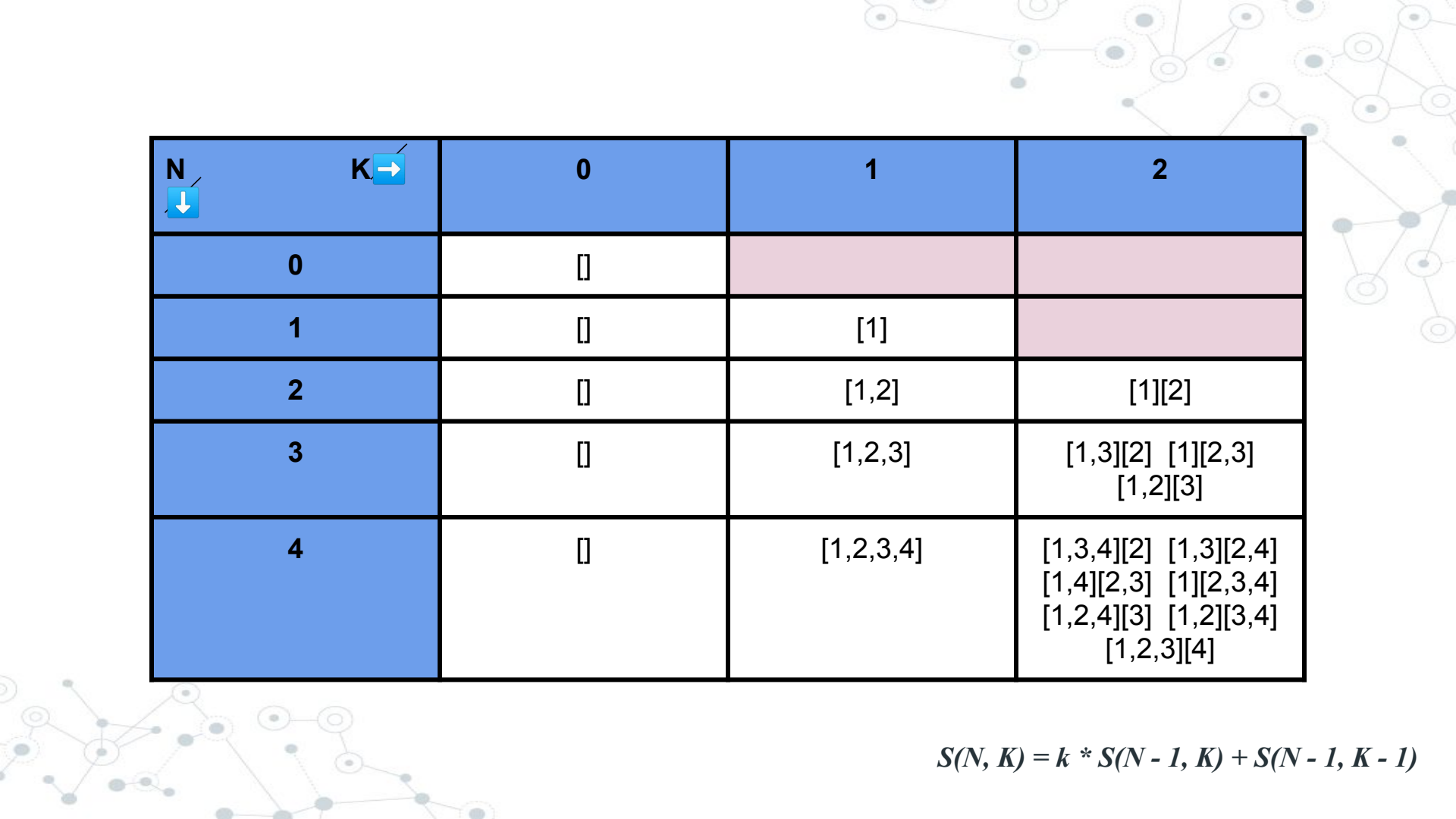
N ↓	K →	0	1	2
0		[]		
1		[]	[1]	
2		[]	[1,2]	[1][2]
3		[]	[1,2,3]	
4		[]	[1,2,3,4]	

$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$



<div> <div>N</div> <div>↓</div> </div> <div> <div>K</div> <div>→</div> </div>	0	1	2
0	[]		
1	[]	[1]	
2	[]	[1,2]	[1][2]
3	[]	[1,2,3]	[1,3][2] [1][2,3] [1,2][3]
4	[]	[1,2,3,4]	

$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$



N ↓	K →	0	1	2
0		[]		
1		[]	[1]	
2		[]	[1,2]	[1][2]
3		[]	[1,2,3]	[1,3][2] [1][2,3] [1,2][3]
4		[]	[1,2,3,4]	[1,3,4][2] [1,3][2,4] [1,4][2,3] [1][2,3,4] [1,2,4][3] [1,2][3,4] [1,2,3][4]

$$S(N, K) = k * S(N - 1, K) + S(N - 1, K - 1)$$

Pruned Brute Force

Truck capacity = 30

Demand = {1 : 12, 2 : 8, 3 : 20, 4 : 9}

<div><div>N</div><div>K→</div><div>↓</div></div>	0	1	2
0	[]		
1	[]	[1]	
2	[]	[1,2]	[1][2]
3	[]	[1,2,3]	[1,3][2] [1][2,3] [1,2][3]
4	[]	[1,2,3,4]	[1,3,4][2] [1,3][2,4] [1,4][2,3] [1][2,3,4] [1,2,4][3] [1,2][3,4][1,2,3][4]

Pruned Brute Force

Truck capacity = 30

Demand = {1 : 12, 2 : 8, 3 : 20, 4 : 11}

<div> <div>N</div> <div>K</div> <div>→</div> <div>↓</div> </div>	0	1	2
0	[]		
1	[]	[1]	
2	[]	[1,2]	[1][2]
3	[]	[1,2,3]	[1,3][2] [1][2,3] [1,2][3]
4	[]	[1,2,3,4]	[1,3,4][2] [1,3][2,4] [1,4][2,3] [1][2,3,4] [1,2,4][3] [1,2][3,4] [1,2,3][4]

Performance Comparison

For,
 $K = 4$

N	Dynamic Approach	Pruned Dynamic Approach	Percentage Drop
4	1	1	0 %
5	10	9	10 %
6	65	40	38.4 %
7	350	152	56.5 %
8	1701	359	78.8 %
9	7770	1357	82.5 %
10	34105	1958	94.2 %
11	145750	3674	97.4 %
12	611501	5173	99.1 %

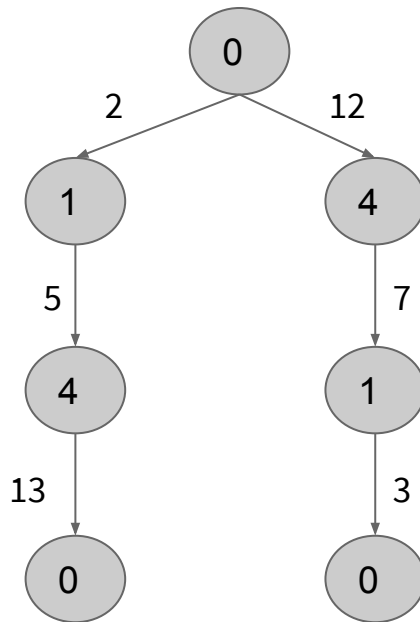
Traveling salesman

- Since I have all the ways that the customers can be served given a set of vehicle
- We need to find which solution is the best
- And also what order the customers should be visited

Traveling salesman

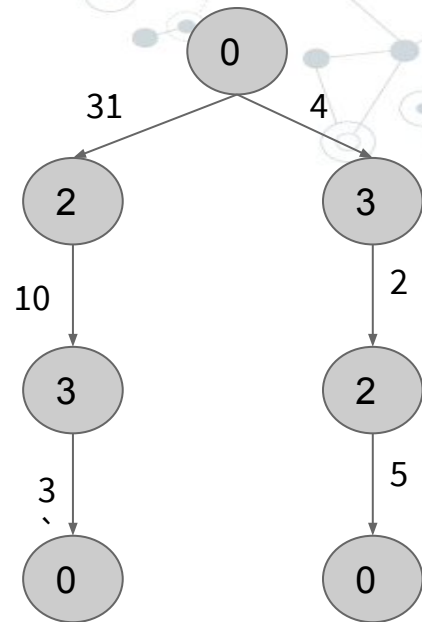
Distance Matrix

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1	3	0	12	4	5
2	5	9	0	10	11
3	3	2	12	0	4
4	13	7	10	8	0



Sum = 20

Sum = 22



Sum = 44

Sum = 11

Result

Truck1 : 0 → 1 → 4 → 0

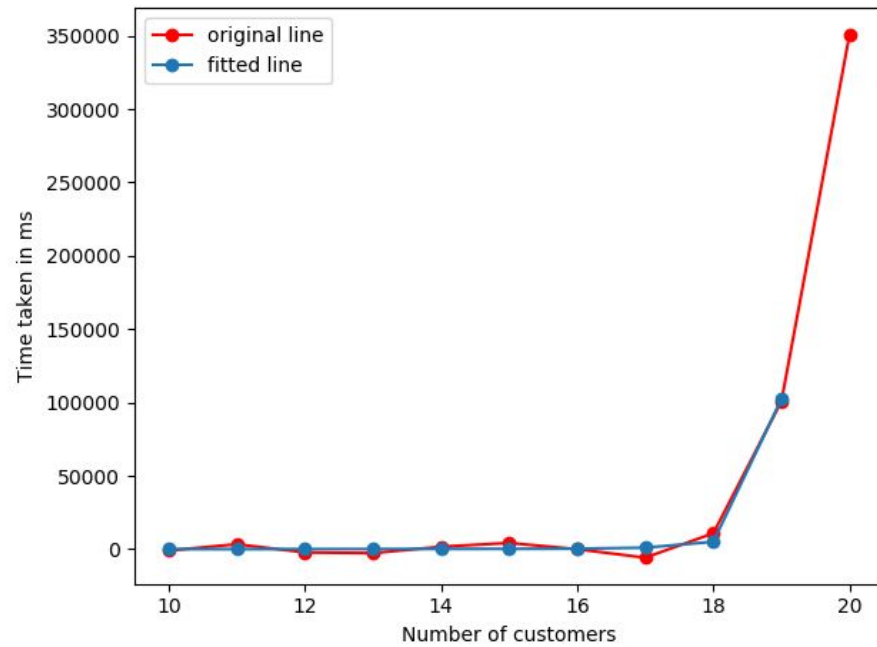
Truck2 : 0 → 3 → 2 → 0

Total Cost = 31

Result comparison

Customers	Time taken(ms)
10	5.0
11	12.0
12	29.0
13	51.0
14	146.0
15	209.0
16	238.0
17	273.0
18	5026.0
19	8447.0

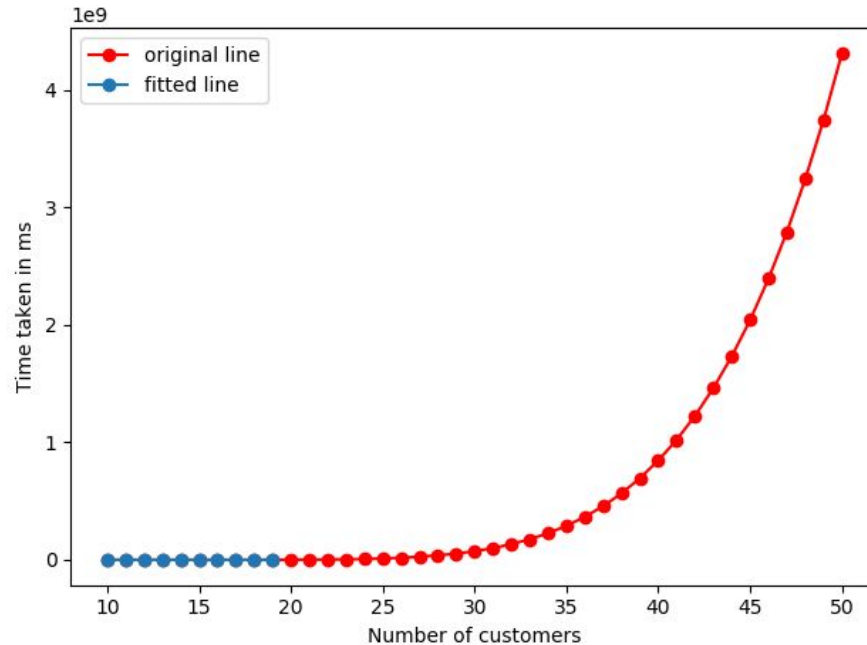
Result



Result

50 Nodes

4.30915618e+09 ms = 49874.49282407 days = **136.64244609334247 years**



Milestones

1. Milestone 1 ✓
 - a. Finding dataset
 - b. Implementation of an exact algorithm
2. Milestone 2 ✓
 - a. Implement an approximate algorithm(Artificial bee colony algorithm)
 - b. Improve the performance of artificial bee colony algorithm
3. Milestone 3
 - a. Parallelize the artificial bee colony algorithm
 - b. Compare and contrast the run-time of all the implementations

A decorative network diagram in the top-left corner, featuring a complex web of interconnected nodes and lines. Some nodes are highlighted with blue circles, and others with blue dots. The diagram is rendered in a light gray color.

Questions?

A decorative network diagram in the bottom-right corner, featuring a complex web of interconnected nodes and lines. Some nodes are highlighted with blue circles, and others with blue dots. The diagram is rendered in a light gray color.

A decorative network diagram in the top-left corner of the slide. It features a complex web of interconnected nodes and lines. The nodes are represented by small circles, some of which are solid blue, some are solid grey, and some are hollow with a blue outline. The lines connecting them are thin and grey. The overall shape of the network is roughly triangular, pointing towards the top-left corner.

Thank you.

A decorative network diagram in the bottom-right corner of the slide. It features a complex web of interconnected nodes and lines, similar in style to the one in the top-left. The nodes are represented by small circles, some of which are solid blue, some are solid grey, and some are hollow with a blue outline. The lines connecting them are thin and grey. The overall shape of the network is roughly triangular, pointing towards the bottom-right corner.