MDVRP

Lucas Tramonte



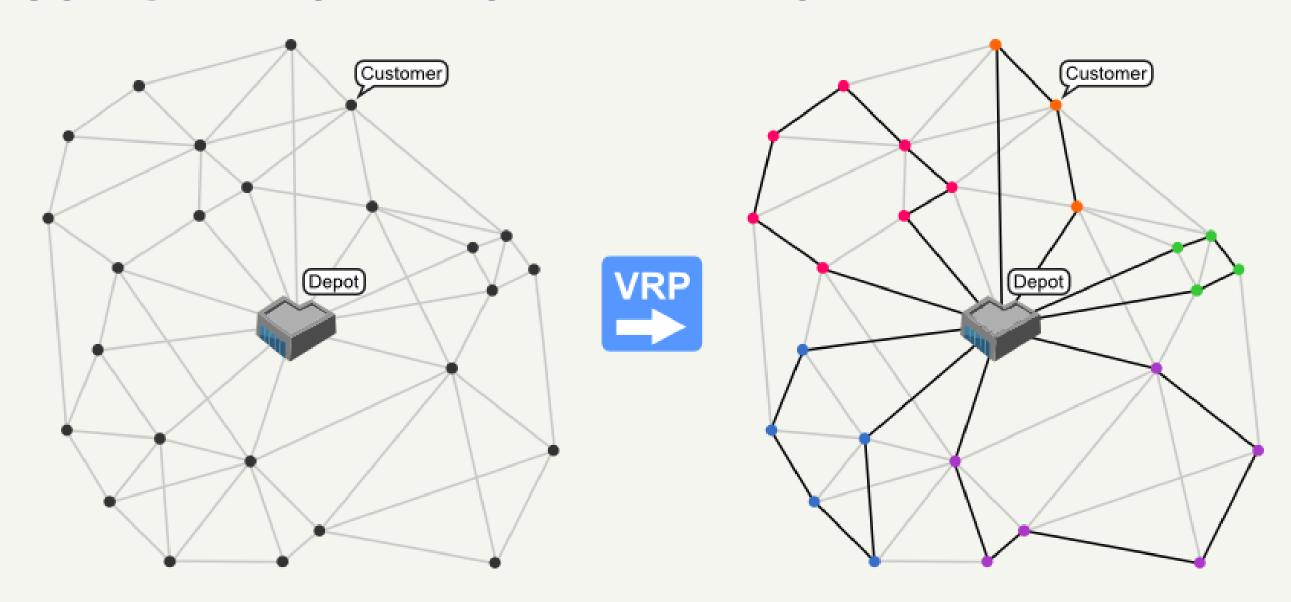
MCGCLU

VEHICLE ROUTING PROBLEM





> COMBINATORIAL OPTIMIZATION



VEHICLE ROUTING WITH MULTIPLE DEPOTS



MAGAZINE LUIZA



MULTIPLE DEPOTS



SEARCH FOR DELIVERY ROUTES



CUT COSTS



INCREASE PRODUCTIVITY









OBJECTIVE FUNCTION:

$$min Z = \sum_{i=1}^{N+M} \sum_{j=1}^{N+M} c_{ij} x_{ij}$$



SUBJECT TO:

$$x_{ij} = 0$$
 ou 1 para todo i, j

BINARY VARIABLE



SUBJECT TO:

$$x_{ij} = 0$$
, para todo $i = j$

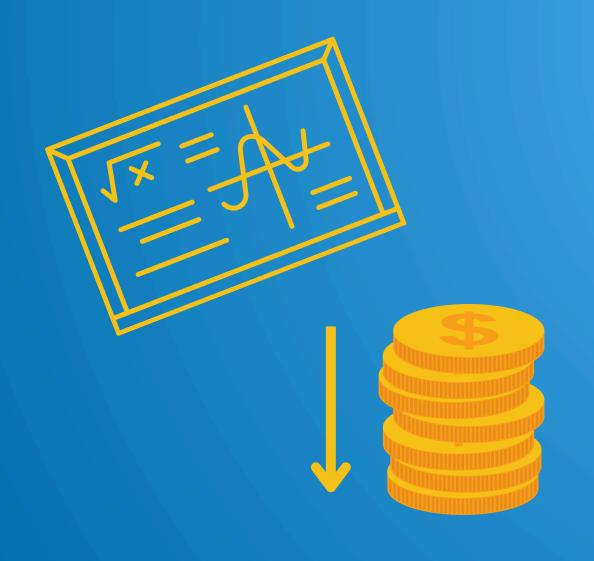
$$x_{ij} = 0$$
,
 $para i = N + 1, N + 2, ..., N + M$
 $e j = N + 1, N + 2, ..., N + M$



CANNOT HAVE A CITY AS ORIGIN AND DESTINATION



CANNOT LEAVE ONE WAREHOUSE AND GO DIRECTLY TO THE OTHER



SUBJECT TO:

$$\sum_{i=1}^{N+M} x_{ij} = 1 \ para \ j = 1, 2, ..., N$$

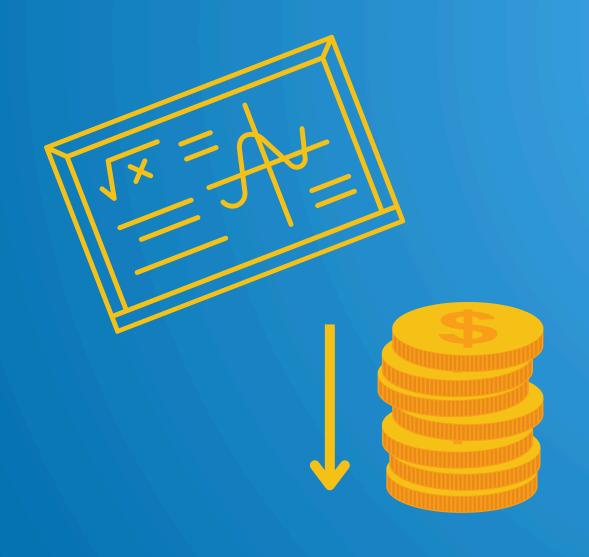
$$\sum_{j=1}^{N+M} x_{ij} = 1 \ para \ i = 1, 2, ..., N$$



DESTINATION CITY IS VISITED ONLY ONCE



ALL CITIES MUST BE VISITED



SUBJECT TO:

$$\sum_{i=N+1}^{N+M} \sum_{j=1}^{N+M} x_{ij} = V$$

$$\sum_{j=N+1}^{N+M} \sum_{ij} x_{ij} = V$$



ALL VEHICLES MUST BE USED



THE MODEL DISTRIBUTES VEHICLES



SUBJECT TO:

$$\sum_{j=1}^{N+M} x_{ij} = V_i, para i = N+1, N+2, ..., N+M$$

$$\sum_{i=1}^{N+M} x_{ij} = V_{j}, para j = N+1, N+2, ..., N+M$$



ALL VEHICLES MUST BE USED



FIXED NUMBER OF VEHICLES PER DEPOT



SUBJECT TO:

$$u_i - u_j + Px_{ij} \le P - Q_i \ para \ 1 \le i \ne j \le N$$

 $y_i - y_j + Lx_{ij} \le L - 1 \ para \ 1 \le i \ne j \le N$

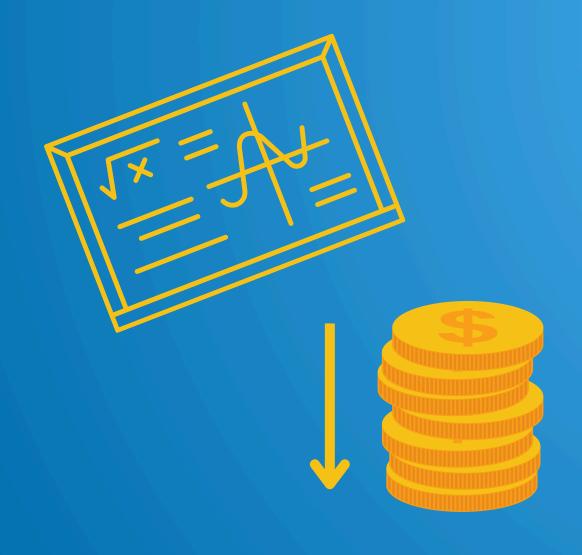


CAPACITY RESTRICTION

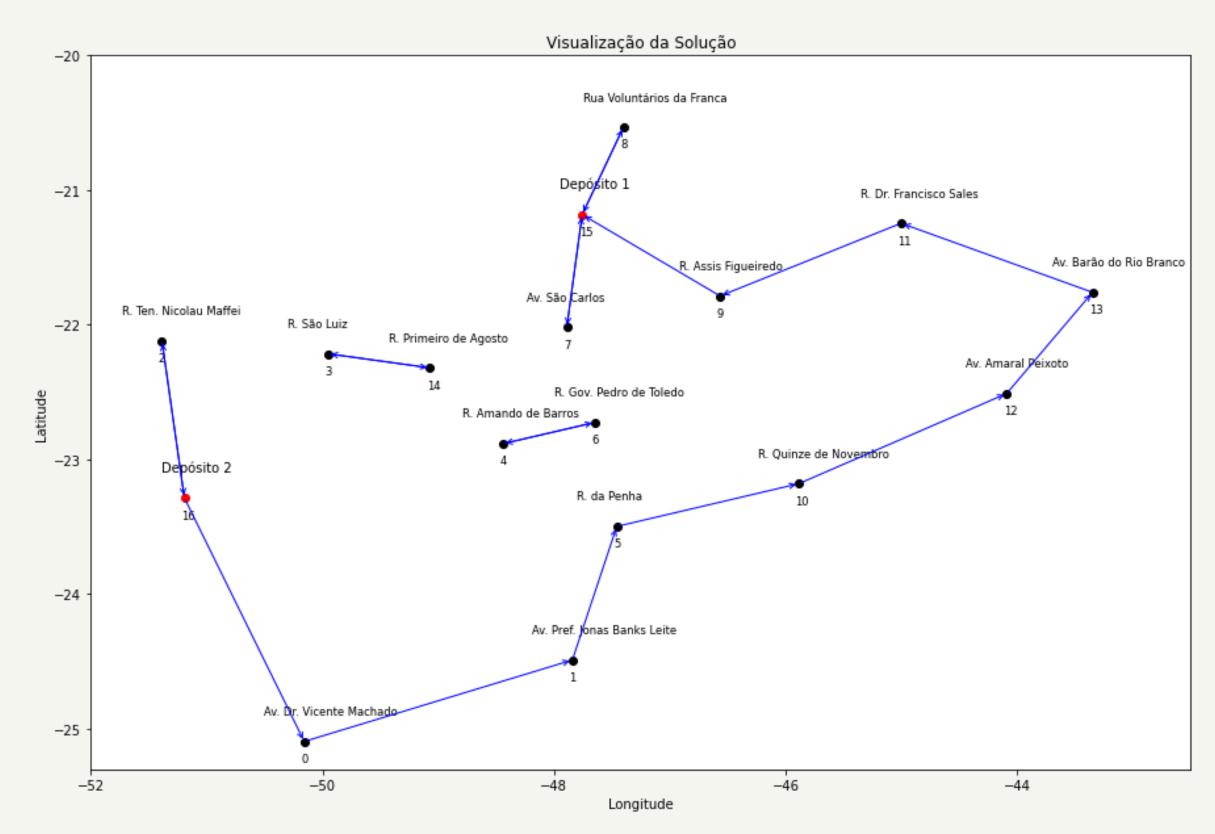


RESTRICTION ON DELETING SUB-ROUTES

SOLUTION



EXAMPLE OF A SOLUTION WITHOUT BREAKING DISCONNECTED SUB-ROUTES



COMPUTATIONAL EXPERIMENT

CHOOSING THE LOCATION OF DISTRIBUTION CENTERS AND STORES:

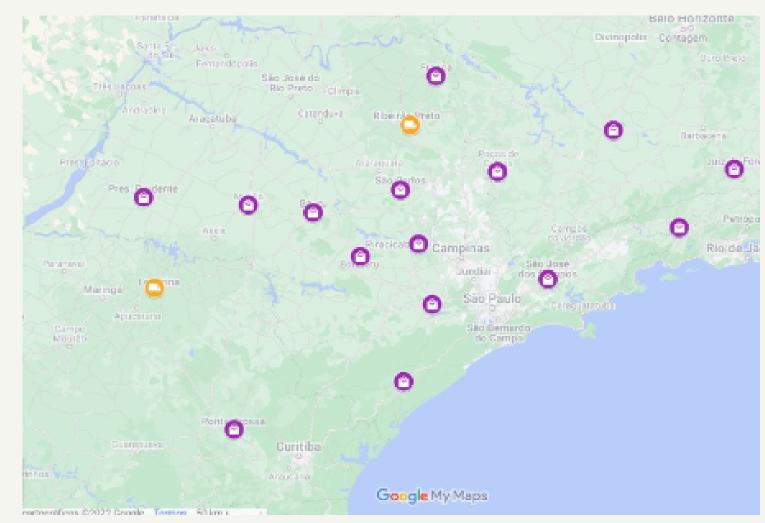


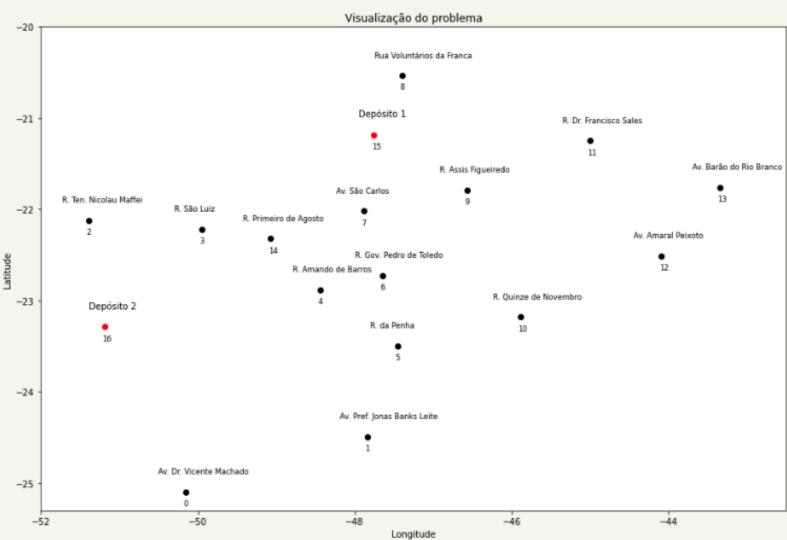
15 STORES AND 2
DISTRIBUTION CENTERS



SP, MG, PR and RJ







COMPUTATIONAL EXPERIMENT



API



CALCULATING THE DISTANCES
BETWEEN:





> STORES AND DEPOTS



GENERATE DISTANCE MATRIX

DISTANCE MATRIX



Matriz de distâncias

							1	PHOLITIZ	ue uibi	antolas	1						
0	0.0	354.6	435.4	396.2	394.7	419.7	467.9	573.2	721.3	673.9	639.6	878.6	863.4	1050.1	431.8	633.5	281.0
п.	359.4	0.0	538.6	439.9	298.6	158.1	324.0	400.4	564.0	421.3	287.0	571.8	510.7	697.5	390.1	476.2	542.9
М.	432.8	539.5	0.0	194.9	367.2	475.4	494.4	449.8	536.3	601.7	643.0	918.4	866.7	1053.5	308.5	460.8	159.8
m -	393.5	496.5	193.0	0.0	203.0	355.3	298.7	262.2	355.9	414.0	522.9	745.5	746.6	933.3	106.7	280.4	200.3
47	392.3	298.2	366.4	202.3	0.0	157.0	115.6	152.6	321.7	281.2	324.5	599.9	548.3	735.0	94.9	233.9	370.7
Ľή·	416.4	156.7	493.7	373.0	174.1	0.0	109.1	198.1	385.4	255.9	185.9	460.6	409.6	596.4	265.6	297.6	498.0
ω.	464.9	319.8	493.4	298.7	115.1	108.5	0.0	97.3	287.5	193.9	223.7	443.9	447.4	634.2	215.9	199.6	497.7
þa.	570.4	396.4	472.0	284.1	152.3	198.9	97.5	0.0	187.3	183.5	294.5	514.7	518.2	704.9	172.0	99.4	476.3
60 -	720.9	563.7	537.1	358.4	325.0	388.2	290.3	190.0	0.0	254.7	461.8	336.2	685.5	586.5	299.3	91.6	554.4
6 -	671.4	420.4	601.3	413.4	281.5	257.0	195.2	182.8	259.1	0.0	308.2	256.0	369.7	460.4	301.3	195.2	605.5
я.	642.9	284.9	643.1	522.4	323.4	186.6	223.9	294.8	458.5	306.3	0.0	404.0	229.3	416.1	414.9	370.7	647.3
Π.	879.4	569.2	921.3	746.0	601.7	465.0	444.3	515.3	338.1	287.1	405.4	0.0	286.6	250.5	633.9	389.3	925.6
77	865.7	507.6	865.8	745.2	546.2	409.4	446.6	517.6	681.3	368.1	226.0	287.5	0.0	180.8	637.7	593.5	870.1
В.	1054.1	696.1	1054.3	933.6	734.7	597.9	615.6	686.6	586.3	458.4	414.5	249.1	181.3	0.0	805.2	624.9	1058.6
14	428.6	388.6	307.1	106.5	95.1	247.4	190.9	150.0	298.1	301.8	415.0	633.3	638.7	825.4	0.0	210.2	311.4
51	630.8	473.6	464.5	285.8	235.0	298.1	200.2	100.0	88.1	196.4	371.7	390.0	595.4	627.5	209.3	0.0	481.8
16	279.7	508.5	160.2	200.2	370.5	478.7	497.7	453.2	552.5	605.0	646.3	921.7	870.0	1056.8	311.8	477.0	0.0
	ó	i	ź	3	4	5	6	ż	8	ģ	10	'n	12	13	14	15	16

- 1000

800

600

- 400

- 200

-0

COMPUTATIONAL EXPERIMENT

1ST APPROACH:



VARY ONLY THE NUMBER OF VEHICLES

WHAT ARE THE BENEFITS OF WORKING WITH A LARGER FLEET?





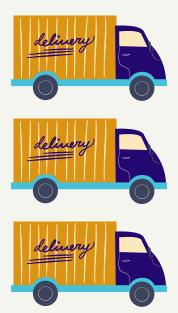
COMPUTATIONAL EXPERIMENT

CASES ANALYZED:

2 VEHICLES



3 VEHICLES



4 VEHICLES

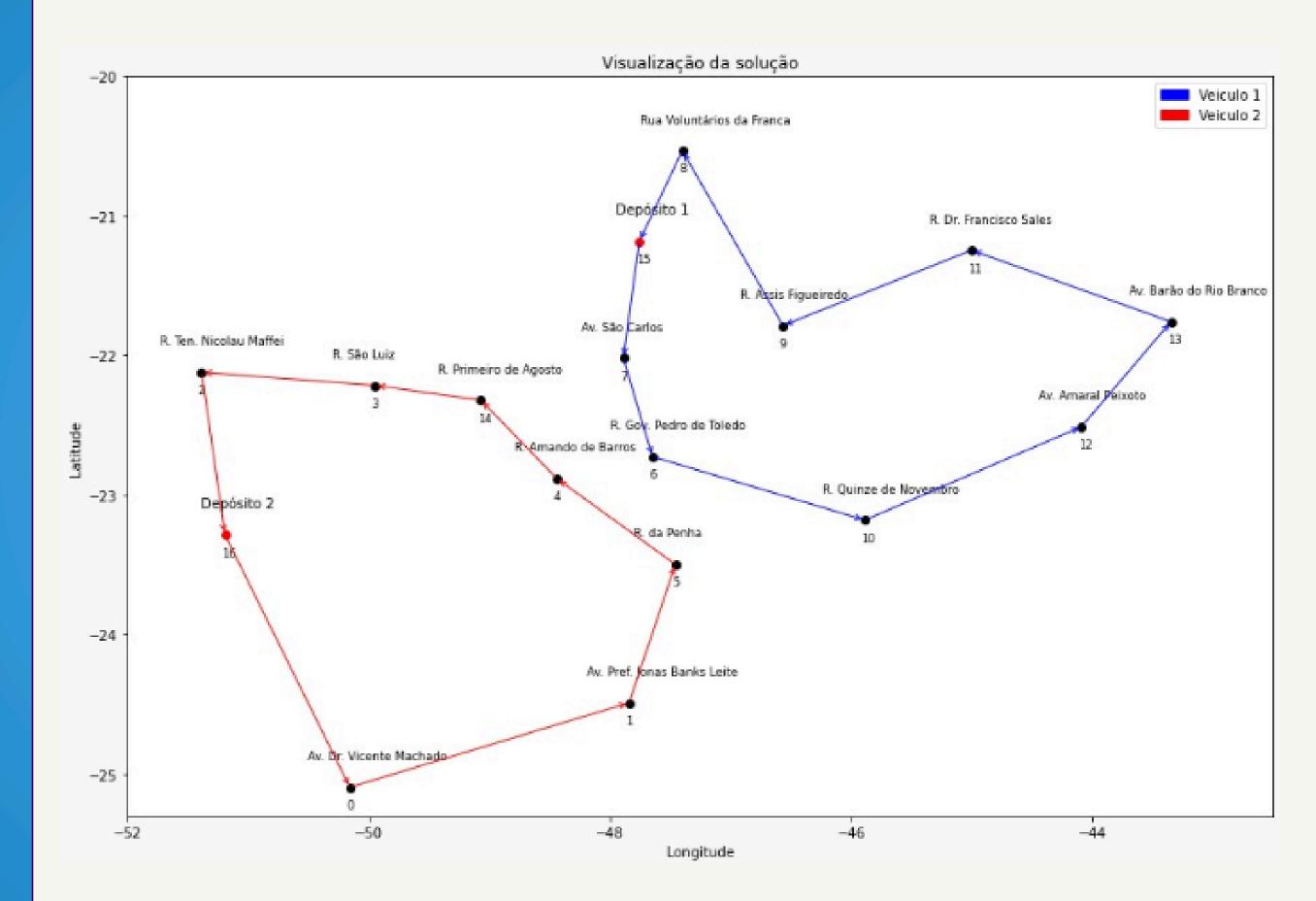


RESULTS

NUMBER OF VEHICLES	OBJECTIVE FUNCTION (km)	DISTANCE PER VEHICLE (km)
2	3190,070	1595,035
3	3223,344	1074,448
4	3386,440	846,610

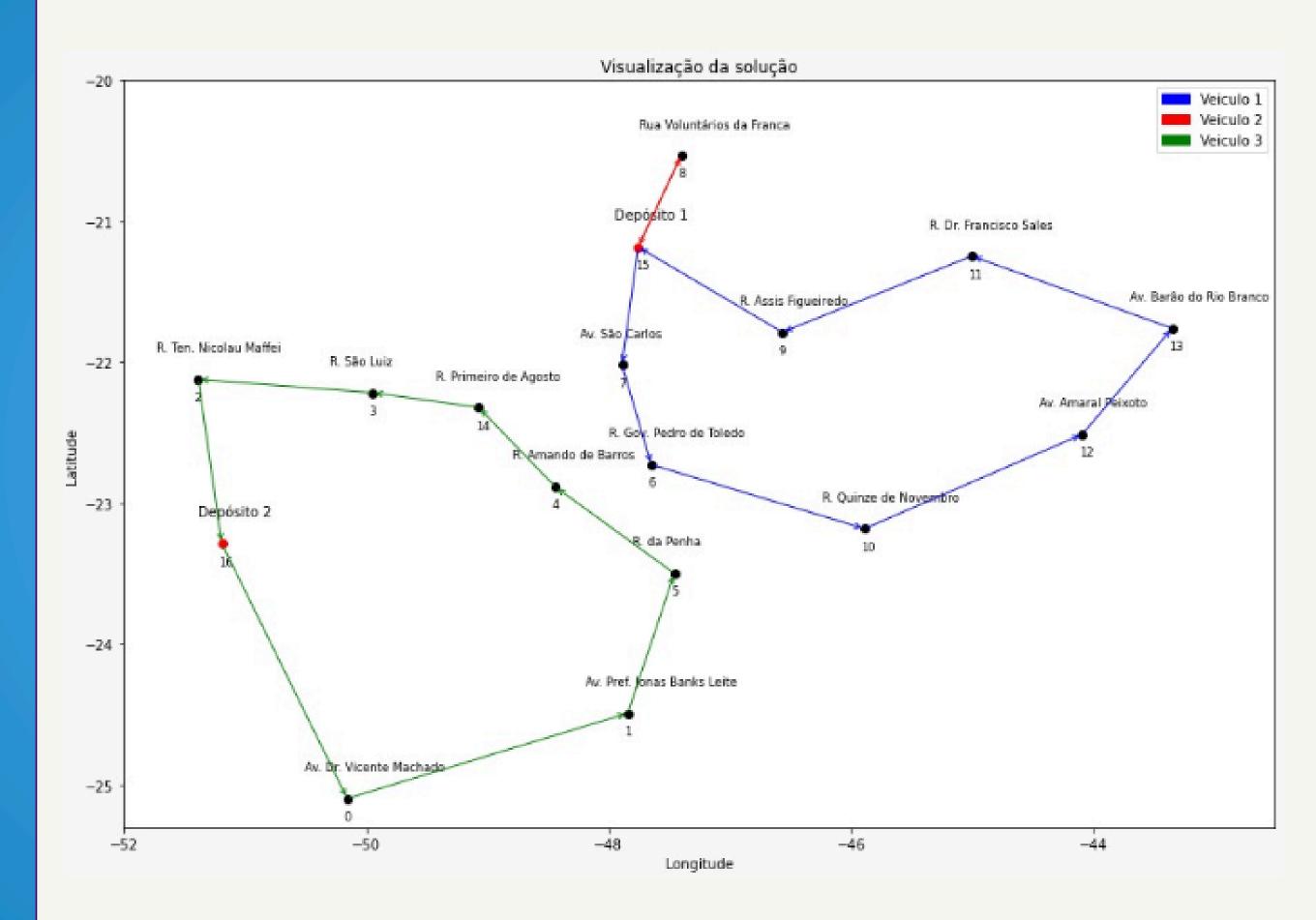
> 2 VEHICLES





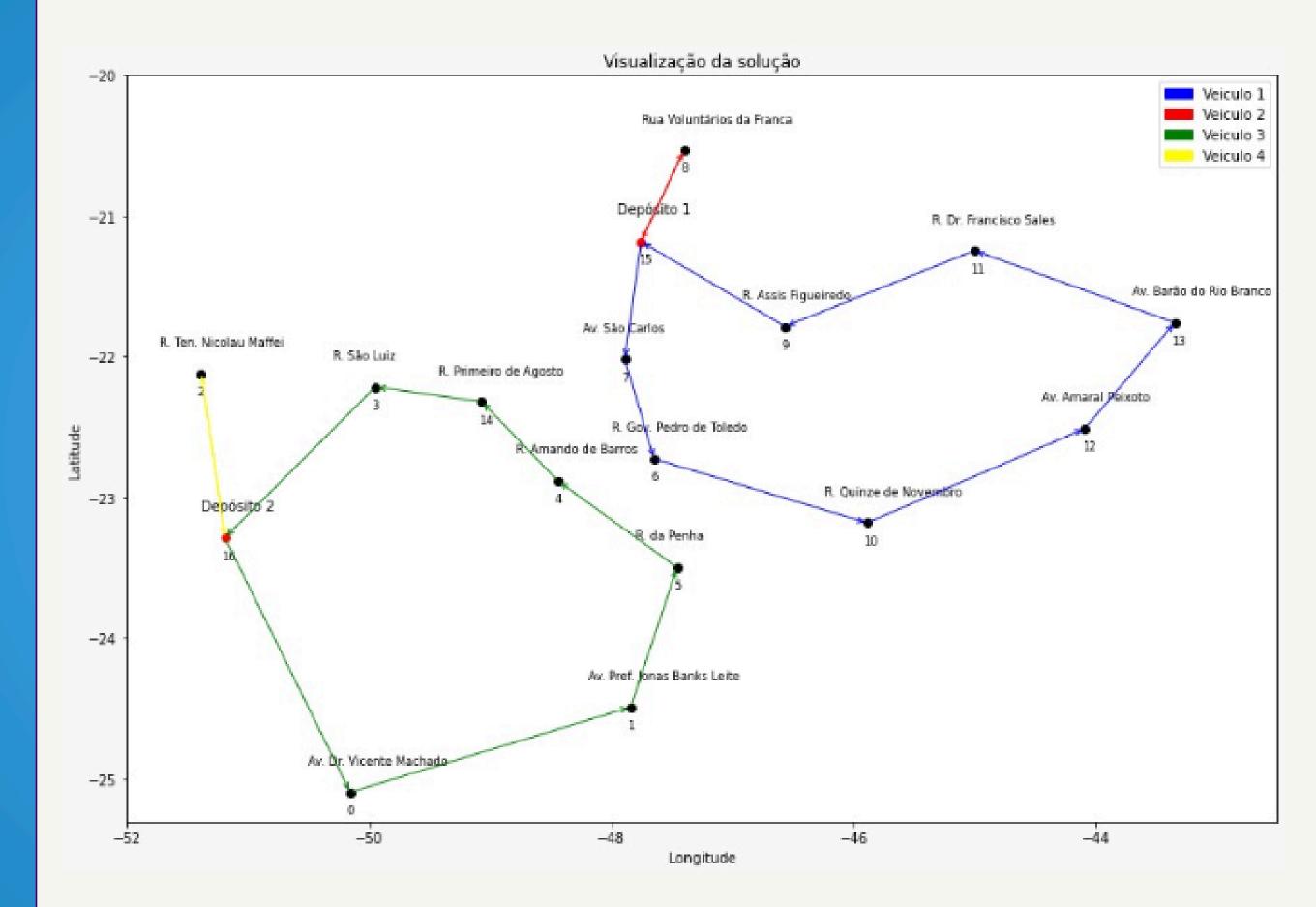
3 VEHICLES





4 VEHICLES





COMPUTATIONAL EXPERIMENT

2ª ABORDAGEM:



DIFERENTES NÚMEROS DE VEÍCULOS



RESTRIÇÃO DE QUANTIDADE MÁXIMA (L) DE PONTOS QUE PODEM SER VISITADOS POR UM MESMO VEÍCULO

SOLUÇÕES ÓTIMAS MAIS FIÉIS À REALIDADE

COMPUTATIONAL EXPERIMENT

CASES ANALYZED:

4 VEHICLES











5 VEHICLES











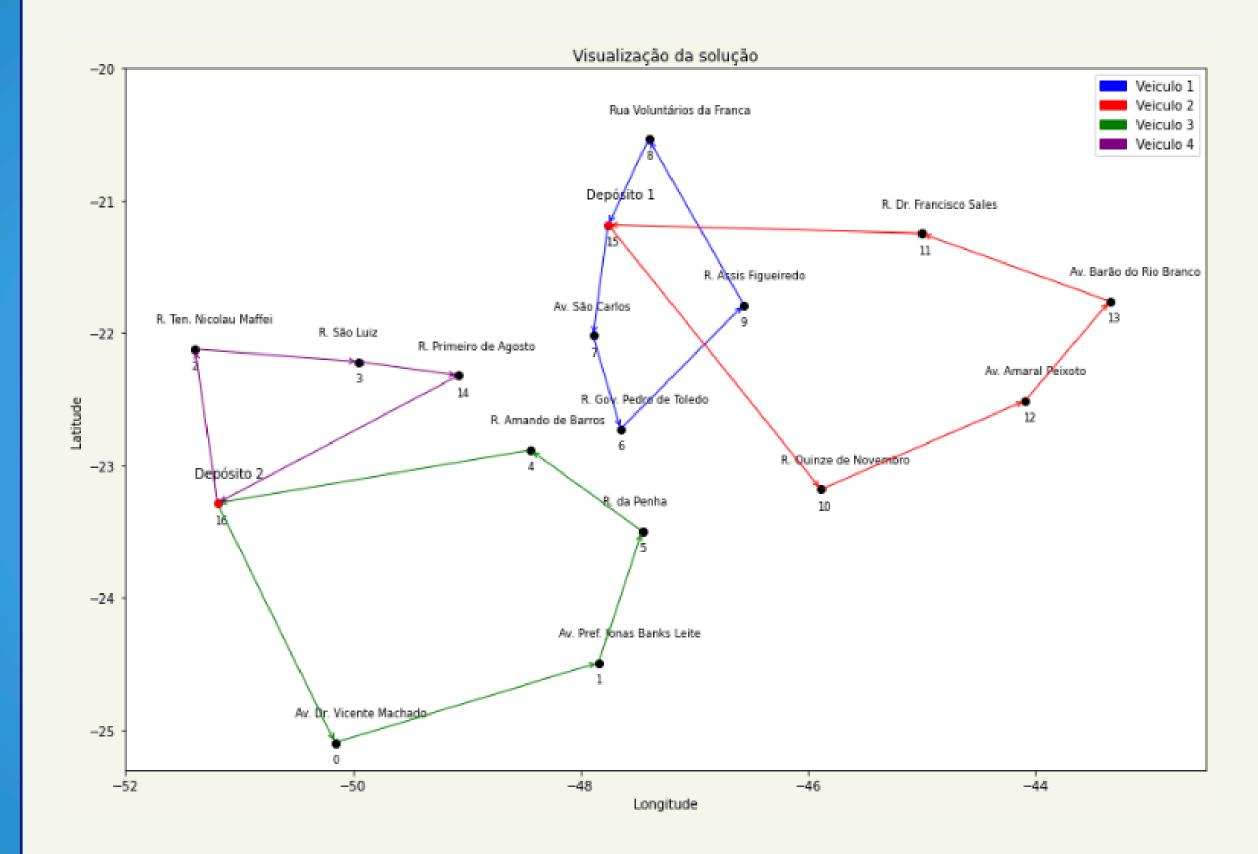
$$L = 3$$

RESULTS

NUMBER OF VEHICLES	MAXIMUM POINTS PER VEHICLE (L)	OBJECTIVE FUNCTION (km)	DISTANCE PER VEHICLE (km)		
4	4	4249,801	1062,450		
5	3	4592,503	918,501		

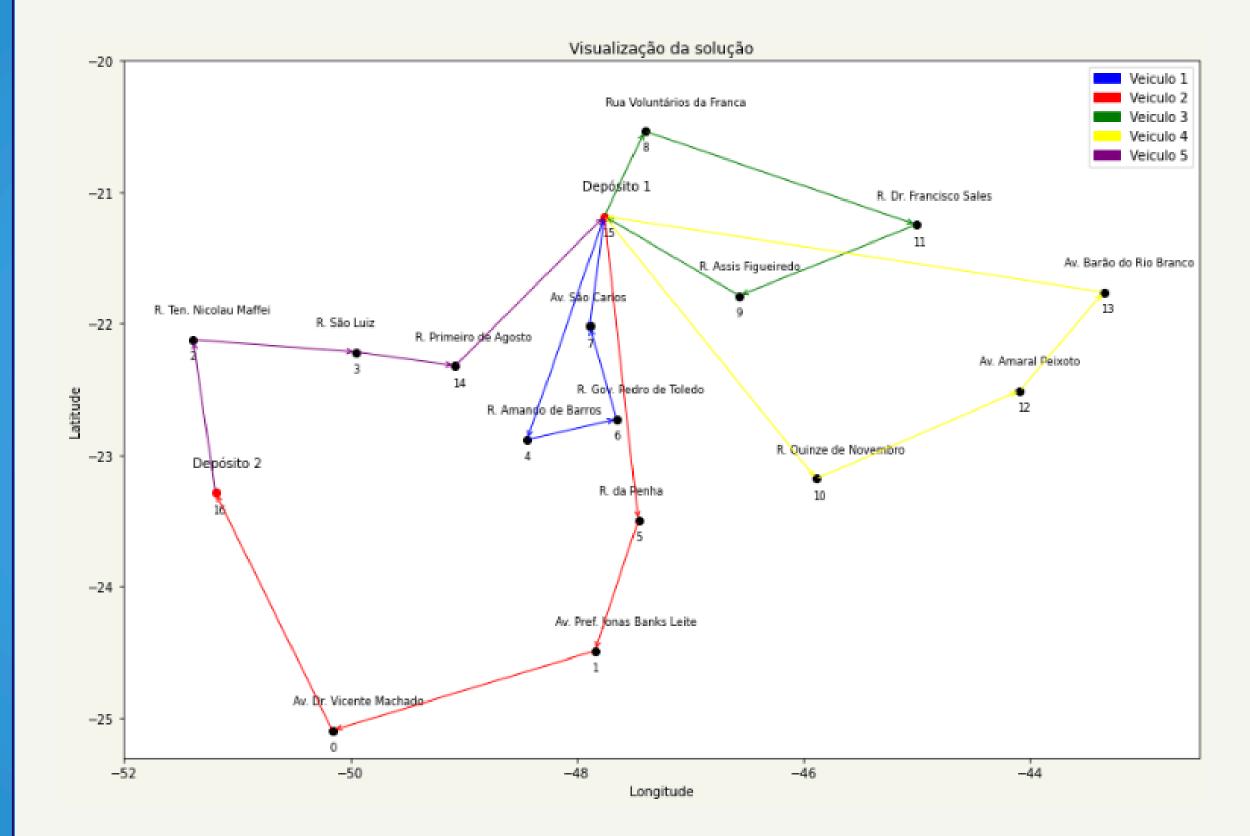
L=4 4 VEHICLES





L=3
5 VEHICLES

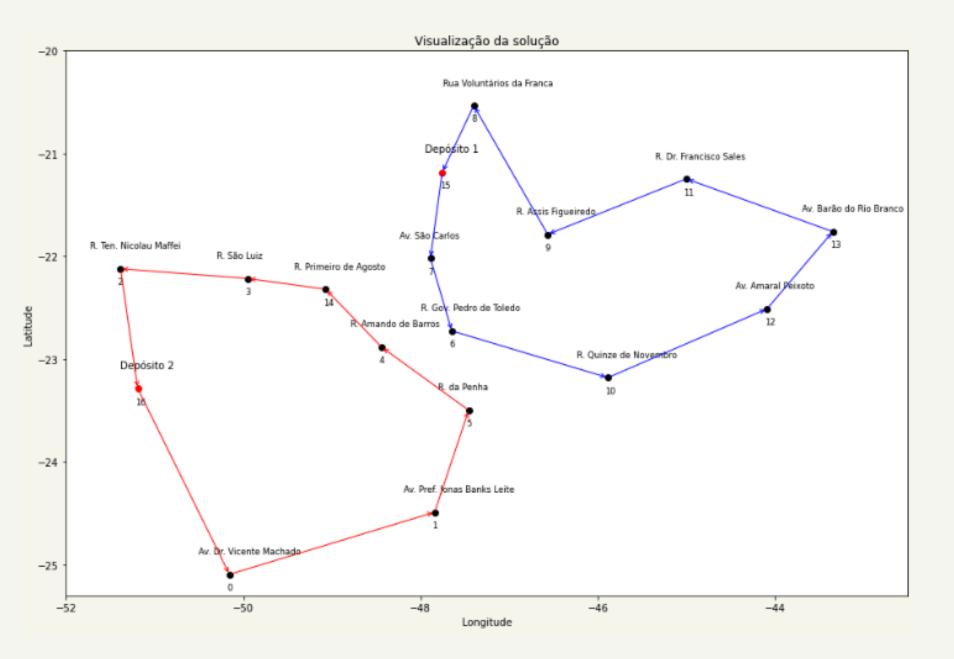




ANALYSIS OF RESULTS

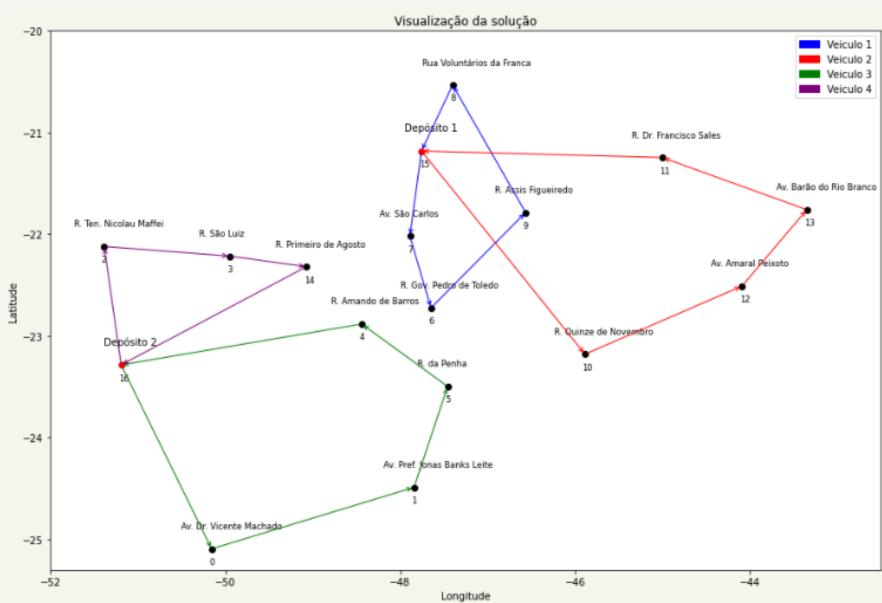
THE 2 MOST INTERESTING APPLICATIONS ARE:

2 VEHICLES



4 VEHICLES

L = 4



RESULTS

NUMBER OF VEHICLES	MAXIMUM POINTS PER VEHICLE (L)	OBJECTIVE FUNCTION (km)	DISTANCE PER VEHICLE (km)
4	4	4249,801	1062,450
2	•	3190,070	1595,035

CONCLUSIONS



DELIVERY ROUTES THAT MINIMIZE
THE DISTANCE TRAVELED





THOROUGH ANALYSIS OF LOGISTICS CAN REDUCE COSTS



INCREASED EFFICIENCY



BUSINESS COMPETITIVENESS



THANKYOU! QUESTIONS?

