Milital And Market 18 1980 Problem: Emergency Medical Response

The Emergency Service Coordinator (ESC) for a county is interested in locating the county's three ambulances to best maximize the number of residents that can be reached within 8 minutes of an emergency call. The county is divided into 6 zones and the average time required to travel from one zone to the next under semi-perfect conditions is summarized in the following Table 1.

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The state of the s	Phone	THE WOLL	Average Trave	el Times (min.)		Kline
Zones	1	2	3	4	5	6
1	1	8	12	14	10	16
2 ,30	8	1	.30 6	18	16	16
33	12 %	18	1.5	3 12	63	4 %
4	16	14 🖟	4 \$	7 1 T	16 ×16	12
5	18	16	10	4	2	dillille 2
6	16	18	4	12	2	2

Table 1: Average travel times from Zone *i* to Zone *j* in semi-perfect conditions.

Matitude Art 1/2 1/8 The population in zones 1, 2, 3, 4, 5 and 6 are given in Table 2 below:

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	The Market of the Control of the Con
Zones	Population
	50,000
2	80,000
3	30,000
4	55,000
5	35,000
11 The 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	20,000
Total	270,000

Table 2: Population in each Zone

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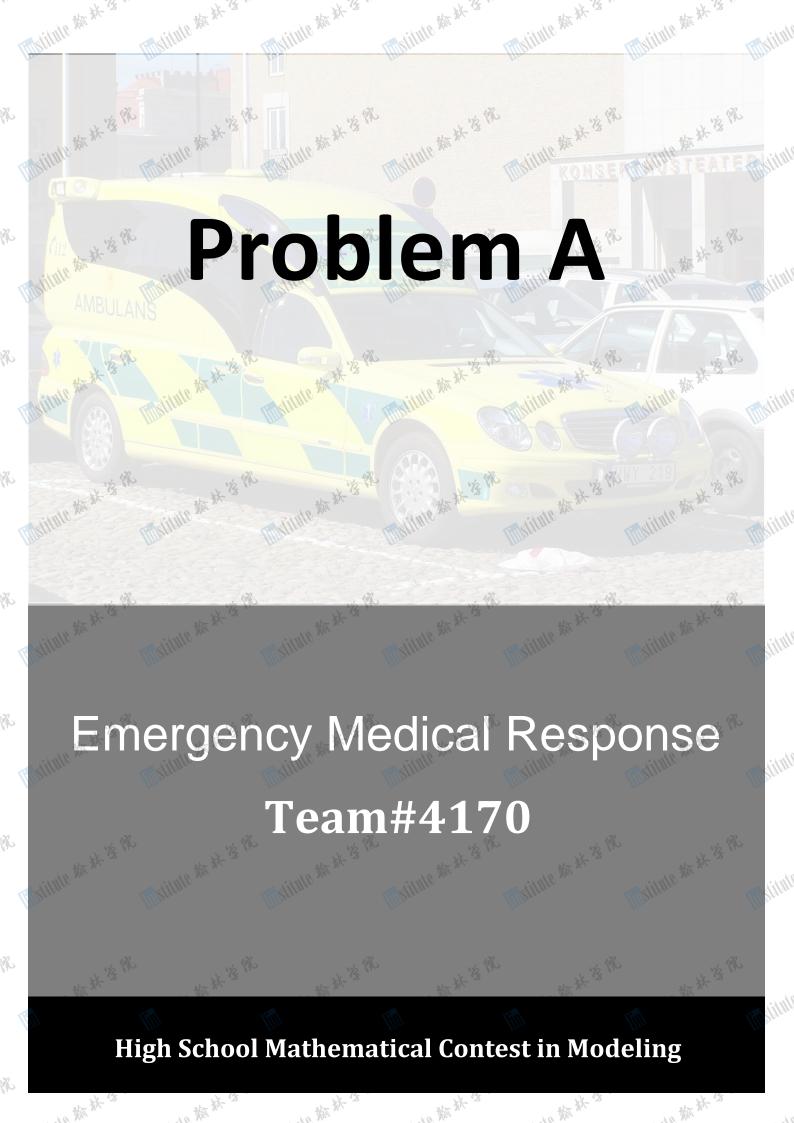
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- 1. Determine the locations for the three ambulances which would maximize the number of people who can be reached within 8 minutes of a 911 call. Can we cover everyone? If not, then how many people are left without coverage?
- 2. We now have only two ambulances since one has been set aside for an emergency call; where should we put them to maximize the number of people who can be reached within the 8 minute window? Can we cover everyone? If not, then how many people are left without coverage?
- 3. Two ambulances are now no longer available; where should the remaining ambulance be posted? Can we cover everyone? If not, then how many people are left without coverage?
- 4. If a catastrophic event occurs in one location with many people from all zones involved, could the ESC cover the situation? How do counties or cities design for those rare but catastrophic events?

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5. In addition to the contest's format, prepare a short 1-2 page non-technical memo outlining your recommendations from your model and analysis finding for the ESC.

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Team Control Number: 4170 Problem Chosen: A

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Summary

solutions when simulating the real situation in the county. To simulate the realest situation, we analyze the average travel time table and find the shortest time from another In order to best maximize the number of residents that can be reached as soon as Militate Star 14 'S another.

> Firstly, to determine the locations for 3 ambulances, we develop the first model not only regardless of the cost times in a zone but also considering the cost of travel times in a zone. When the cost times in the zone are ignored, ambulances located in Zone 2, 5 and 6 can cover the most residents, which is 300,000 people. In order to reduce the cost, we locate the 3 ambulances in Zone 1, 2, and 5 or Zone 1, 2, and 6, and all the zones can be covered within 6 minutes. When consider travel times in a zone, 3 ambulances are ditute the At 13 PR located in Zone 2, 4 and 5 or Zone 2, 5, and 6, the zones covered maximize. And there are 275,000 people covered.

Secondly, after drawing the conclusion and giving out the answer of the first question, our team further discuss the model how we determine the location of m ambulances in an area which is divided into n zones. And we build a clear and detailed model which can be Mistate Start 18 18 Pripiple star st. 1.3 used to almost every situation. It is also with 'regardless the travel time in a zone' as well as 'considering the travel time in a zone'.

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Then we substitute *m*, *n* into our new model. And we gain the best solutions of the second and the third question using the second model. The simulation results validate that our model is correct.

After that, we test our model in Shanghai. We choose 8 famous locations and analyze the average time from one location to another. We also choose 3 locations as the starting point. The result is that all the locations can be reached. This result proves that our model is feasible in the real life.

At last, to solve the forth question, we turn the problem into a realistic example to analyze it. At the time we verify our model, we use a real event as an example. We choose the case of earthquake which happened in Wenchuan, China. We search a lot of information on the Internet and get useful pictures and texts. After analyzing them, we make matrixes and use our models to solve the problem. The simulation result is that most of the stricken areas can be covered, but some roads are damaged so that several places cannot be covered.

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Marithus Mark of 180 1. Problem Restatement
What an ESC of o What an ESC of a certain county does is to locate ambulances and dispatch them to a particular place in the county which is divided into 6 zones.

> According to the Average Travel Times Table, the time which it takes to travel from Zone i to Zone j and the time that it takes from Zone j to Zone i are different. Maybe it is because there are one-way roads or one-way traffic congestion. Besides, the time given by the table which it takes to travel from one zone to another may be not the shortest. For example, the time it takes from Zone 4 to Zone 5 is 16 minutes. But if the ambulance goes to Zone 6 and then leave for Zone 5, it just takes 12 minutes. This is shorter than 16 minutes. The ESC has to maximize the number of people who can be reached within 8 minutes.

Ind the philipping So as to maximum the people or zones to be covered, we make efforts to make and improve our model so that we can simulate the situation more real.

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2. Assumptions and Justification

Assumptions of Model 1, 2, 3:

- 1. There's no accident on the way such as traffic jams, storms, etc.
- The time that an ambulance travels from one spot to another is certain.
- 3. The population of each zone won't change.
- 4. Things such as machines of the ambulances run well.
- There are hospitals in each zone.

i here ar 3. Analysis of the Average Time

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It is easy to find a lot of ways from one zone to another in the picture, and their lengths are different.

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Makitute Make 13 2 5 Zone 1 3 4 7 1 1 12 14 10 16 8 2 8 1 6 18 16 16 12 18 1.5 12 6 4 3 阿外洛州 16 14 4 1 16 12 4 18 4 5 16 10 2 2 18 2 6 16 4 12 2

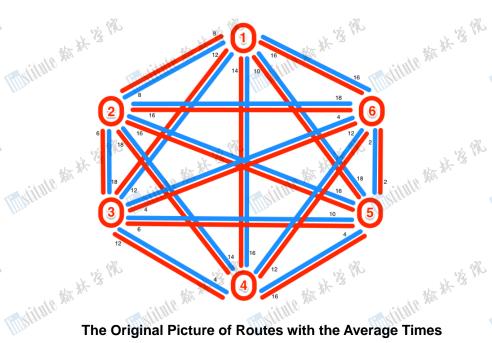
Tab. 1: The Original Average Time

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The Original Picture of Routes with the Average Times

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3.1 Variables Definition

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	the route f	from Zone j to Zone i.)	
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moditute the the committee of the commit	3.1 Varia	bles Definition	称状
	Variable	Description	
IIII	$A_{\rm l}$	A matrix of average travel times from Zone i to Zone j in semi-perfect conditions	
- Y- Y	A_2	A matrix of the shortest travel times, regardless of the travel time in one zone, from Zone <i>i</i> to Zone <i>j</i> in semi-perfect conditions	W. B. W.
	A_3	A matrix with simplified information based on A_2 which marks the number larger than '8' as '0' and the rest as '1' so that '1' means that the ambulance can reach the place within 8 minutes	0
	A_4	A matrix of the shortest travel times, considering the travel time in one zone, from Zone <i>i</i> to Zone <i>j</i> in semi-perfect conditions	
insitute the the state of the s	A_5	A matrix with simplified information based on A_4 which marks the number larger than '8' as '0' and the rest as '1' so that '1' means that the ambulance can reach the place within 8 minutes	ALTO ACC
	A_6	A matrix with simplified information based on A ₂ which marks the number larger than '6' as '0' and the rest as '1' so that '1' means that the ambulance can reach the place within 6 minutes	
maitute of the committee of the committe	A_7	A matrix with simplified information based on A_2 which marks the number larger than '4' as '0' and the rest as '1' so that '1' means that the ambulance can reach the place within 4 minutes	1909
	Pop	A matrix which shows the population of each zone	
maitate An A '3	W.	In the the state of the state o	频光光像
Ministration of the second	mytitu	The state of the s	5 ~

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$$A_{1} = \begin{pmatrix} 1 & 8 & 12 & 14 & 10 & 16 \\ 8 & 1 & 6 & 18 & 16 & 16 \\ 12 & 18 & 1.5 & 12 & 6 & 4 \\ 16 & 14 & 4 & 1 & 16 & 12 \\ 18 & 16 & 10 & 4 & 2 & 2 \\ 16 & 18 & 4 & 12 & 2 & 2 \end{pmatrix} A_{2} = \begin{pmatrix} 1 & 8 & 12 & 14 & 10 & 12 \\ 8 & 1 & 6 & 18 & 12 & 10 \\ 12 & 18 & 1.5 & 10 & 6 & 4 \\ 16 & 14 & 4 & 1 & 10 & 8 \\ 18 & 16 & 6 & 4 & 2 & 2 \\ 16 & 18 & 4 & 6 & 2 & 2 \end{pmatrix} A_{3} = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 \end{pmatrix}$$

$$A_4 = \begin{pmatrix} 1 & 10 & 14.5 & 16 & 13 & 17 \\ 10 & 1 & 8.5 & 20 & 16.5 & 14.5 \\ 14.5 & 20.5 & 1.5 & 14.5 & 9.5 & 7.5 \\ 18 & 16 & 6.5 & 1 & 14.5 & 12.5 \\ 21 & 19 & 11.5 & 7 & 2 & 6 \\ 19 & 21 & 7.5 & 11 & 6 & 2 \end{pmatrix} A_5 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{pmatrix} A_6 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 \end{pmatrix}$$

$$A_7 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{pmatrix}$$

$$Pop = (50 \ 80 \ 30 \ 55 \ 35 \ 20)$$

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3.2 Process for the Shortest Path

Critical Path Method:

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In A₁, we shorten the average travel time from one zone to another. For example, we use Zone 2 to Zone 6 as series of data to get the shortest time. The table is the shortest time.

		1	2	3	4	5	6	
	i = 1	127.	<u>1</u>	80	8	∞	8	v32 .
. 10%	i = 2	8 3	. **	<u>6</u>	18 3	16	16	13 Th
The Other	i = 3	<u>8</u>	The State	atur:	16	12	10	The state of the s
Tillytille	i = 4	The state of the s	RIII.	TillAllon	16	12	<u>10 </u>	
		-			-		-	•

3.3 Conclusion

The shortest average time, regardless of the time in one zone, under semi-perfect conditions from Zone *i* to *j* is showed in the following table.

Tab. 2:Shortest Average Travel Times Regardless the Travel Time in a Zone

Zone	1	2	3	4	5	6	
1	1	8	12	14	10	12	
2	.8	1 4	₩ 6	18	12	10	1/2 V
3	12	18	1.5	加入10	6	4	版於。
4	16	dill114	4 titill	1	dill110	8/11/11/8	
Min	111	Tin.	Illin	111	Ma	Illin	•
	Zone 1 2 3	1 1 2 8 3 12	1 1 8 2 8 1 3 12 18	1 1 8 12 2 8 1 6 3 12 18 1.5	1 1 8 12 14 2 8 1 6 18 3 12 18 1.5 10	1 1 8 12 14 10 2 8 1 6 18 12 3 12 18 1.5 10 6	1 1 8 12 14 10 12 2 8 1 6 18 12 10 3 12 18 1.5 10 6 4

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	5	18	16	6	4	2	2
	6	16	18	4	6	2	2
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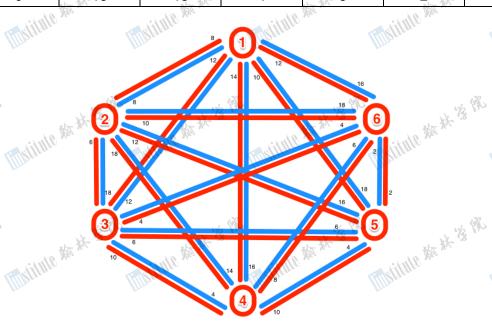
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The Picture of Routes with the Shortest Average Times Regardless of Travel Times in a Zone (When i≺j, every red row shows the route.)

the route from Zone *j* to Zone *i*.)

The shortest time, considering the time in one zone, under semi-perfect conditions from Zone i to j is showed in the following table.

Tab. 3: Shortest Average Travel Times Considering the Travel Time in a Zone

Zone	NOTO .	2	3	4	5	6	AT X
THE STATE OF THE S	1	Millil 10	14.5	16	13	17//////	
2	10	1	8.5	20	16.5	14.5	
3	14.5	20.5	1.5	14.5	9.5	7.5	
4	18	16	6.5	1,4	14.5	12.5	
5	21	19	11.5	7	2	6	水水多
6	19	21	7.5	11	1111/16 A	2	
4	2 3 4 5 6	3 14.5 4 18 5 21	2 10 1 3 14.5 20.5 4 18 16 5 21 19	2 10 1 8.5 3 14.5 20.5 1.5 4 18 16 6.5 5 21 19 11.5	2 10 1 8.5 20 3 14.5 20.5 1.5 14.5 4 18 16 6.5 1 5 21 19 11.5 7	2 10 1 8.5 20 16.5 3 14.5 20.5 1.5 14.5 9.5 4 18 16 6.5 1 14.5 5 21 19 11.5 7 2	2 10 1 8.5 20 16.5 14.5 3 14.5 20.5 1.5 14.5 9.5 7.5 4 18 16 6.5 1 14.5 12.5 5 21 19 11.5 7 2 6

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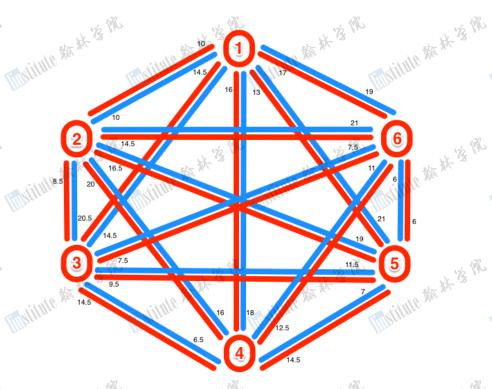
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Maritud Mar # 13 198 The Picture of Routes with Shortest Average Times Considering the Travel Time in a Zone

(When i < j, every red row shows the route from Zone i to Zone j, and every blue row shows the route from Zone *j* to Zone *i*.)

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4.1 Variables

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In the optimal emergency medical response model, we define some variables as such:

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	Variable Name	Description 22	A32
- X	k	Index variable	THE WAY THE
Matitale state of the control of the	n	The number of zones	The William
Till tilling	m	The number of available ambulances	F
	r_k	The number of people in Zone k	
ato Mr.	v_k	Zone k	*************************************
Makitate An A S		The location of the first ambulance	Vr _{eo}
	v_y	The location of the second ambulance	
THE STATE OF THE PROPERTY OF T	v _z	The location of the third ambulance	板外海外
linstitute	Tillstitute	Marithus Marithus Marithus Marithus Marithus Marithus	

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The pick altitude with the second	$\frac{v_{a_i}}{s(v_x,v_k)}$	The location where the i ambulance is located The value of row x, column k in A ₃
THINKING.	X 3 V K 7	William William William William
	$S(V_y,V_k)$	The value of row y, column k in A ₃
	$S(V_z,V_k)$	The value of row z, column k in A ₃
> ,,,	S _k	The number of ambulances which can reach Zone k
*****	y _k	Whether Zone k can be reached within 8 minutes
Weiting the state of	$\phi(V_x,V_k)$	The value of row x, column k in A ₅
Miller	$\phi(V_y,V_k)$	The value of row y, column k in A ₅
	$\phi(V_z,V_k)$	The value of row z, column k in A ₅
	Z _k	Whether Zone k can be reached within 8 minutes
> "	The variables in	this table will be used in all of the following models.
H Total Oliver	如如	· · · · · · · · · · · · · · · · · · ·
THE SHIP STATE OF THE STATE OF	4.2 Model 1	middle marking marking
	We have designed	ed an optimal emergency medical response model for the determinations

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We have designed an optimal emergency medical response model for the determinations of the locations of three ambulances.

4.2.1 Modeling Under semi-r-

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Under semi-perfect conditions and regardless of the travel time in one zone, we strive for $\sum_{i=1}^{6}$

$$\max \sum_{k=1}^{6} y_{k} r_{k}$$

$$\begin{cases} y_{k} = \begin{cases} 0, & s_{k} = 0 \\ 1, & s_{k} \ge 1 \end{cases} \\ s_{k} = s(v_{x}, v_{k}) + s(v_{y}, v_{k}) + s(v_{z}, v_{k}) \end{cases}$$

$$v_{x} \in \{1, 2, 3, 4, 5, 6\}$$

$$v_{y} \in \{1, 2, 3, 4, 5, 6\}$$

$$s.t. \begin{cases} v_{z} \in \{1, 2, 3, 4, 5, 6\} \\ s(v_{x}, v_{k}) \in A_{3} \\ s(v_{y}, v_{k}) \in A_{3} \end{cases}$$

$$s(v_{z}, v_{k}) \in A_{3}$$

$$v_{x} \neq v_{y} \neq v_{z}$$

$$r_{k} \in Pop, k \in \{1, 2, 3, 4, 5, 6\}$$

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A. Locations regardless the travel time in a zone

Following the model, we substitute for every possible x, y, z. And we programme and gain the following conclusion. ('Program solution_initial' is in the appendix; input $A_k = A_3$)

Table 4

				Table 4			
S about 1		The num	3 · ½	oulances which co	over the	The location of the ambulances	本外
THIS SHITE SAN	No.	111/18	2	4	6	Agithia Maria and a saithia	None (

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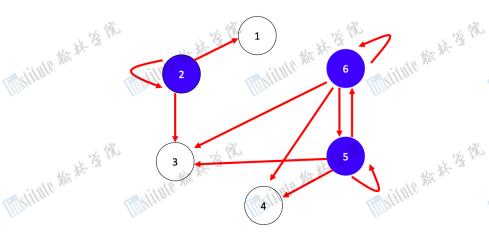
	1	2	2	2	12	1	1,72	1	2	5	. 22
THE WHITE THE STATE OF THE PERSON OF THE PER	2	2	3 2	2	31	1	31	1	2	6	一张多
The Patrice	3	118 3/10	1	2 3/19	1	OFFE STIFF	2	110 %	3	4,10	1912
Tillstroke	4 11181	1	1 1111	2	1	2	2	MSUL	3	111.5	
	5	1	1	2	1	2	2	1	3	6	
	6	1	1	2	2	1	2	1	4	5	
	%7	1	12 VII	2	·/2 20	1	.,2%	1	4 %	6	1/2 3/1
张	8	1. 冰	1	2	2	2	2	1	米 5	6	海外。
matitude of the state of	9		1	3	1	atilities a	2	2	3	4/11/1	V _e
Million	10	1	1 11111	3	1	2	2	2	3	5	
	11	1	1	3	1	2	2	2	3	6	
	12	1	1	3	2	1	2	2	4	5	.30
, Y Y	13	1 ,	13 VI	3	2	1	2	2	4 4	6	13 W
THE BOX OF THE	14	加加加	1	3/10 **	2	2 1	2	2 %	5	6	海水
Maritute the the	(The fire	st six colu	ımns of 7	<i>able 4</i> m	ean the r	numbers	of ambula	ances tha	t cover th	nis area.	•
	The last	three co	lumns of	D mean t	he location	n of 3 am	nbulances	s. There a	re 14 way	vs.)	

a. The places where the ambulances locate that can cover the maximum

If an ambulance covers a whole zone, that ambulance covers everybody in this zone. The solutions that have the maximum sum of the position. This attitude of the state of t by the three ambulances is the best solution.

in the appendix; input $A_k = A_3$) So, the best solution is that when the 3 ambulances are placed in **Zone 2, Zone 5 and Zone 6**. the number $A_k = A_3$ placed in Zone 2, Zone 5 and Zone 6, the number of the people who can be covered

When there's a call, the 3 ambulances should go like what the following picture shows.



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b. The places where the ambulances locate that cost least money or fuel regardless of the travel time in a zone

Mysitute ## # 3 Team #4170 Page 11 of 30

traveling on the way.

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the longest time besides that of 8 minutes on the way. We programme through A_6 and gain the following conclusion. ("Program 3-1."

the following conclusion. ('Program solution_ initial' is in the appendix; input $A_k = A_6$) It is

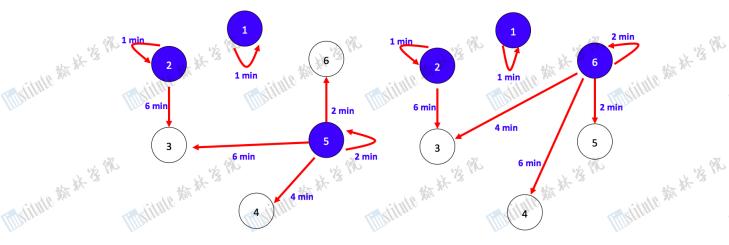
that when we locate the 3 ambulances in Zone 1, Zone 2, Zone 5 or Zone1, Zone 2, Zone 6, all the zones can be covered within 6 minutes. And the numbers of the people covered are the same. There are 300,000 people covered.

Secondly, we use 4 minutes as a stand to further discuss A7 because the time of 4 minutes is the longest time besides that of 6 minutes on the way. We programme through A₇ and gain the following conclusion. ('Program solution_ initial' is in the appendix; input

 $A_k = A_7$) It is that ambulances **cannot** cover each zone within 4 minutes.

So, using this method, the best solution is to locate the 3 ambulances in Zone 1, Zone 2, Zone 5 or Zone1, Zone 2, Zone 6. And there are 300,000 people covered.

When there's a call, the 3 ambulances should go like what the following pictures shows.



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We get A₄ in a situation that we consider the ambulance traveling in each zone. For example, if an ambulance travels from Zone 1 to Zone 6. we should consider the stravely from Zone 1 to Zone 6. example, if an ambulance travels from Zone 1 to Zone 6, we should consider then sum of time from Zone 1 to Zone 1, Zone 1 to Zone 6 and Zone 2 to Zone 6. expression.

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$$\max \sum_{k=1}^{6} z_{k} r_{k}$$

$$\begin{cases}
z_{k} = \begin{cases}
0 & \phi_{k} = 0 \\
1 & \phi_{k} \ge 1
\end{cases} \\
\phi_{k} = \phi(v_{x}, v_{k}) + \phi(v_{y}, v_{k}) + \phi(v_{z}, v_{k}) \\
v_{x} \in \{1, 2, 3, 4, 5, 6\} \\
v_{y} \in \{1, 2, 3, 4, 5, 6\} \\
v_{z} \in \{1, 2, 3, 4, 5, 6\} \\
\phi(v_{x}, v_{k}) \in A_{5} \\
\phi(v_{y}, v_{k}) \in A_{5} \\
\phi(v_{z}, v_{k}) \in A_{5} \\
v_{x} \neq v_{y} \neq v_{z} \\
r_{k} \in Pop, k \in \{1, 2, 3, 4, 5, 6\} \end{cases}$$
a stand and mark the number larger than '8' as '0' and the re

Maritate Mar # 13 1980 We use 6 minutes as a stand and mark the number larger than '8' as '0' and the rest as '1' so that '1' means that the ambulance can reach the place within 8 minutes. After we conclusion. ('Program solution_ initial' is in the appendix; input $A_k = A_5$) It is that we cannot cover every zone by 3 ambulances Astitute Am At 13 182

We programme and gain the following conclusion. ('Program solution_ initial' is in the appendix; input $A_k = A_5$) activities was by 18 18

11/190	11111	20.		141120		17	11120		177	1120.	141120	
IIII	III	The n	The numbers of the ambulances which cover the zone The location of the largest no the of people							The largest no.		
Mylilite Mark 19	No.		2	3			5 6	ambulances			covered (thousand)	**************************************
THE DELLE	1	1 10	1	1	0	0	1,10	逐 1	2	3	180	狐
III TITULE	2		1	MAL	1	0 (1110	1	2	4	215	
	3	1	1	0	1	1	1	1	2	5	240	
	4	1	1	1	0	1	1	1	2	6	215	
a wil	4.5	1	0	2	1	.0	1	1	3	4	185	16 8
the state of the s	6	1	\ 0	1	1. 洪	1	2	本外位	3	5	210	水水水
otitute of	7		0	2	0	1	2/1	1	3	6	185	Non-
IIII	8	1	0	Magazin	2	1		1	4	5	245	
	9	1	0	2	1	1	1	1	4	6	220	
	10	1	0	1	1	2	2	1	5	6	245	
. 4	111	0	12 1	2	1	12 O	1	2 %	3	4	215	3
institute state of	12	0	於1	1	、旅水	1	2	2	3	5	240	频
Stitille	13		1	2	0	1	2/1/2	2	3	6	215	
	IIII			IIII				•		111	In	

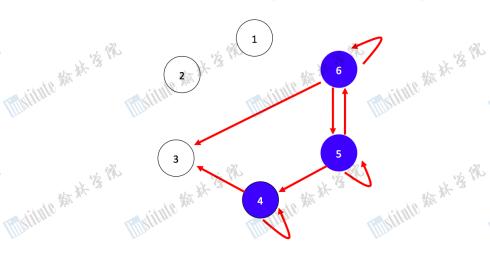
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	14	0	1 🚜	1	2		1	2	4	5	275	. 22
- X-Y	15	0	从18	2	13	B 1	1	2	4	6	250	***
The ork of the state of	16	0 70	1	1	(C 1)	2	. 2	2	5	6	275	\$10 .
Till Strong	17	0	0	2	2	1	2	3	4	5	245	
	18	0	0	3	1	1	2	3	4	6	220	
	19	0	0	2	1	2	3	3	5	6	245	
6.7	20	0	0, %	2	2	1/2 Z	2	4 %	√ 5	6	280	16 PM
被冰	We ca	n get th	e best s	solution	that wh	en the	3 ambu	lances	are lo	ocated	in Zone 4, Zone 5	松外公
linkitute		101					III Dr.			UV Dr.	ople covered. g picture shows.	Ne-

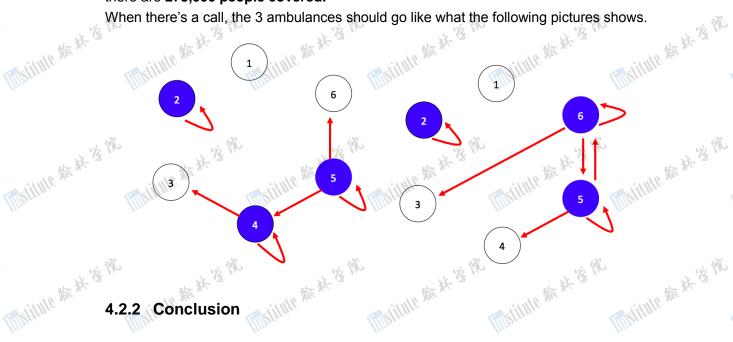
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We programme and gain the following conclusion. ('Program solution_ initial' is in the appendix; input $A_k = A_5$) The best solution is that where " Zone 2, Zone 4, Zone 5 or Zone 2, Zone 5, Zone 6, the zones covered maximize. And there are 275,000 people covered.

Military War 18 When there's a call, the 3 ambulances should go like what the following pictures shows.



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4.2.2 Conclusion

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Maritha Art & Team #4170 Page 14 of 30

> We have turned a complex mathematical problem into a series of expression through a model. And the problem has been worked out. At the same time, we have worked out 2 situations: regardless of the travel time in a zone or considering the travel time in a zone. In the situations of 'Regardless of the travel time in a zone', we have further discussed the two solutions to cost least money and fuel or to cover maximum people. Also, in the situation of 'Considering the travel time in a zone', we have explored the two solutions to cover most zones or people and give out different results.

4.3 Model 2

in the state of th

We have designed an optimal emergency medical response model for the determinations of the locations of two ambulances.

indiating the state of the stat

Under semi-perfect conditions and regardless of the travel time in a zone, we strive for

$$\max \sum_{k=1}^{n} y_{k} r_{k}$$

$$\begin{cases} y_{k} = \begin{cases} 0, & s_{k} = 0 \\ 1, & s_{k} \ge 1 \end{cases} \\ s_{k} = \sum_{i=1}^{m} s(v_{a_{i}} v_{k}) \\ v_{a_{i}} \in \{1, 2, 3, \dots, n\}, & i \in \{1, 2, 3, \dots, m\} \\ s(v_{a_{i}}, v_{k}) \in A_{3} \\ v_{a_{1}} \neq v_{a_{2}} \neq \dots \neq v_{a_{m}} \\ r_{k} \in Pop, k \in \{1, 2, 3, \dots, n\} \end{cases}$$
als 2 and n equals 6

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Militate 新春·養原 It's obvious that m equals 2 and n equals 6.

A. Locations regardless of the travel time in a zone

and gain the following conclusion. ('Program solution_cover' is in the appendix; input $A_k = A_3$; input Pop = Pop)

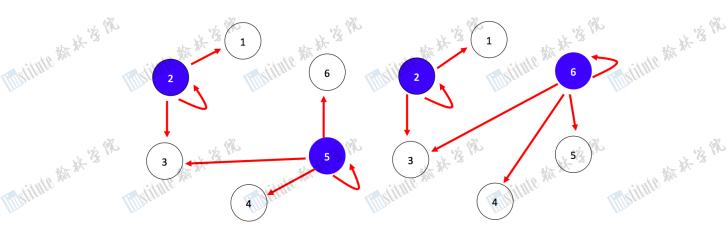
$$A_2$$
; input $Pop = Pop$)

a. The places where the ambulances locate that can cover the maximum people regardless of the travel time in a zone

We gain the best solution through 'Program solution_cover'. ('Program solution_cover' is in the appendix; input $A_k = A_3$; input Pop = Pop) It is that when we locate the two ambulances in Zone 2, Zone 5 or Zone 2, Zone 6, the number of people covered stitute the the state of the st maximize. There are 300,000 people covered.

When there's a call, the 2 ambulances should go like what the following pictures shows.

Maithin san ar 3 Team #4170 Page 15 of 30



b. The places where the ambulances locate that cost least money or fuel regardless of the travel time in a zone

If an ambulance costs least money and fuel, that ambulance spends least time traveling on the way.

Firstly, we use 6 minutes as a stand because the time of 6 minutes is the longest time besides that of 8 minutes on the way. We programme and gain the following conclusion.

Myithte ## # 13 PR ('Program solution_cover' is in the appendix; input $A_k = A_6$; input Pop = Pop) It is that there exists no solution that cost less than that of 8 minutes.

B. Locations considering the travel time in a zone

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We get A4 in a situation that we consider the ambulance traveling in each zone. For time from Zone 1 to Zone 1 to Zone 6, we should consider then sum of time from Zone 1 to Zone 1 to Zone 6 and Zone 6 to Zone 6. Here is the new expression.

$$\max \sum_{k=1}^{n} z_{k} r_{k}$$

$$\begin{cases}
z_{k} = \begin{cases}
0, \phi_{k} = 0 \\
1, \phi_{k} \ge 1
\end{cases} \\
\phi_{k} = \sum_{i=1}^{m} \phi(v_{a_{i}} v_{k}) \\
v_{a_{i}} \in \{1, 2, 3, \dots, n\} , i \in \{1, 2, 3, \dots, m\} \\
\phi(v_{a_{i}}, v_{k}) \in A_{5} \\
v_{a_{1}} \neq v_{a_{2}} \neq \dots \neq v_{a_{m}} \\
r_{k} \in Pop, k \in \{1, 2, 3, \dots, n\}
\end{cases}$$

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Astitute the the 's 182 It's obvious that m equals 2 and n equals 6. We use 6 minutes as a stand and mark the number larger than '8' as '0' and the rest as '1' so that '1' means that the ambulance can reach the place within 8 minutes. After we simplify the matrix, we get A₅. We programme input $A_k = A_5$; input Pop = Pop) It is that we **cannot** cover every zone by 2 ambulances. through A₅ and gain the following conclusion. ('Program solution_cover' is in the appendix;

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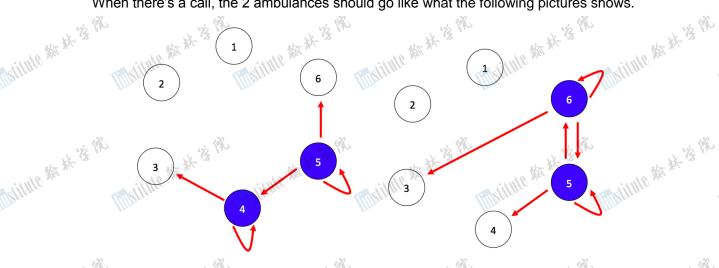
a. The places where the two ambulances locate that can cover the maximum people considering the travel time in a zone

We programme and gain the following conclusion. ('Program solution_cover' is in the appendix; input $A_k = A_5$; input Pop = Pop)

ato XX		The nu	imbers o	of the an	nbulance zone	s which	cover	The local		The largest no. of people
Maritate And At 18	No. Ilyi	tuite saa	2	Militario A	4	Tillstitut?	6	of t ambu		covered (thousand)
	1	1	1	0	0	0	0	1	2	130
×	%2	1	1/2 O/2	1	0, %	0	1 %	%1	3	100
the state of the s	3	1 _{6/20} %	ొ 0	1 1	冰 了	0	0	1	4	135
This willing the	4	111119	0	AdidOllo	1	Titill	1	1	5	160
Illinger	5	1	0	1	0	Illin	1	1	6	135
	6	0	1	1	0	0	1	2	3	130
	.30 7	0	1	1	1 ,30	0	0	2	4	165
1× 1/2	8	0	13 1º	0	1/2 /3/2	1	1, 3	2	5	190
inditute the state of	9	0	1	1. 物	0	1	姬子	2	6	165
Milline	10	0	0	18/1/2	1	Ollin	1	3	4	135
	11	0	0	1	1	1	2	3	5	160
	12	0	0	2	0	1	2	3	6	135
	13	0	0	1	2 %	1	1	4	5	195
等,接 療養 的批准認識	14	0, 1	- ⁶³ O	2 ,,,	水18	1	15- 15- 13	4	6	第 170
Sig africa	15	11/0/12	0	8 21 No	1	2	2	5	6	195

The best solution is that when the two ambulances are located in **Zone 4**, **Zone 5** or **Zone 5**, **Zone 6**, the number of people covered maximize. There are **195,000 people covered**. When there's a call, the 2 ambulances should go like what the following pictures shows.

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b. The places where the ambulances locate that cover most zones

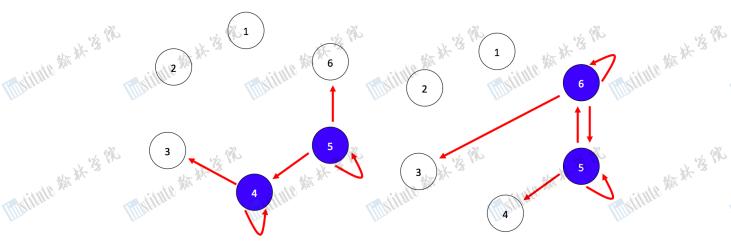
We programme and gain the following conclusion. ('Program solution_cover' is in the

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Mysitute ## ** **

The best solution is that when the two ambulances are located in **Zone 4**, **Zone 5** or **Zone**5, **Zone 6**, the number of people covered maximize. There are **105** and Mylithin the 's When there's a call, the 2 ambulances should go like what the following pictures shows.



4.3.2 Conclusions

Militate Art & PR Our team further discussed the model how we determine the location of m ambulances in an area which is divided into n zones. At the same time, we have worked out 2 situations: solutions to cost least money and fuel or to cover maximum people. Also, in the situation of 'Considering the travel time in a zone', we have explored the two solutions or people and give out all' of 'Considering the travel time in a zone', we have explored the two solutions to cover most zones or people and give out different results

4.4 Model 3

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of the locations of an ambulance. Astitute At X 18 We have designed an optimal emergency medical response model for the determinations

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Under semi-perfect conditions and regardless of the travel time in a zone, we strive for

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$$\max \sum_{k=1}^{n} y_{k} r_{k}$$

$$\begin{cases} y_{k} = \begin{cases} 0, & s_{k} = 0 \\ 1, & s_{k} \ge 1 \end{cases} \\ s_{k} = \sum_{i=1}^{m} s(v_{a_{i}} v_{k}) \\ v_{a_{i}} \in \{1, 2, 3, \dots, n\}, i \in \{1, 2, 3, \dots, m\} \\ s(v_{a_{i}}, v_{k}) \in A_{3} \\ v_{a_{1}} \neq v_{a_{2}} \neq \dots \neq v_{a_{m}} \\ r_{k} \in Pop, k \in \{1, 2, 3, \dots, n\} \end{cases}$$

It's obvious that m equals 1 and n equals 6.

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A. Locations regardless of the travel time in a zone

Following the model, we substitute for every possible x. And we programme and gain the following conclusion. ('Program solution_cover' is in the appendix; input $A_k = A_3$; input

$$Pop = Pop$$
)

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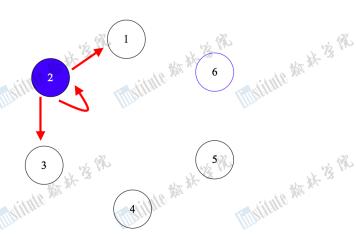
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a. The places where the ambulance locate that can cover the maximum people regardless of the travel time in a zone

in the appendix; input $A_k = A_3$; input Pop = Pop) It is that when we locate the ambulance in **Zone 2**, the number of people covered TWhen there's a call, the ambulance should go like what the following picture shows.

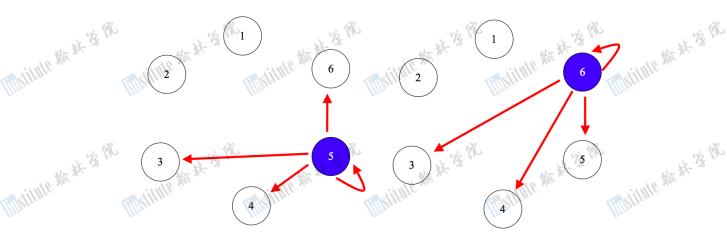


We programme and gain the following conclusion. ('Program solution_cover' is in the

Maritha Art & Team #4170 Page 19 of 30

> appendix; input $A_k = A_3$; input Pop = Pop) It is that when we locate the ambulance in Zone 5 or Zone 6, the number of people covered maximize. There are 140,000 people covered.

When there's a call, the ambulance should go like what the following pictures shows.



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We get A₄ in a situation that we consider the ambulance traveling in each zone. For example, if an ambulance travels from Zone 1 to Zone 6 time from Zone 1 to Zone 1, Zone 1 to Zone 6 and Zone 6 to Zone 6. It's obvious that m equals 1 and n equals 6. Here is the new expression.

quals 1 and n equals 6. Here is the new expression.
$$\max \sum_{k=1}^n z_k r_k$$

$$\begin{cases} z_k = \begin{cases} 0, \phi_k = 0 \\ 1, \phi_k \geq 1 \end{cases} \\ \phi_k = \sum_{i=1}^m \phi(v_{a_i} v_k) \\ v_{a_i} \in \{1, 2, 3, \cdots, n\} \quad , \quad i \in \{1, 2, 3, \cdots, m\} \\ \phi(v_{a_i}, v_k) \in A_5 \\ v_{a_i} \neq v_{a_2} \neq \cdots \neq v_{a_m} \\ r_k \in Pop, \quad k \in \{1, 2, 3, \cdots, n\} \end{cases}$$

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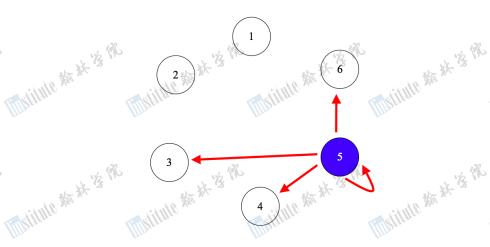
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We use 6 minutes as a stand and mark the number larger than '8' as '0' and the rest as '1' simplify the matrix, we get A_5 . We programme through A_5 and gain the following conclusion. ('Program solution 7. conclusion. ('Program solution_cover' is in the appendix; input $A_k = A_5$; input Pop = Pop) It is that we cannot cover every zone by 1 ambulance.

We programme and gain the following conclusion. ('Program solution_cover' is in the a. The places where the two ambulances locate that can cover the

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appendix; input $A_{\bf k}=A_{\bf 5}$; input ${\it Pop}={\it Pop}$) It is that when we locate the ambulance in Milititle Mark 13 **Zone 5**, the number of people covered maximize. There are **110,000 people covered**. When there's a call, the ambulance should go like what the following picture shows.



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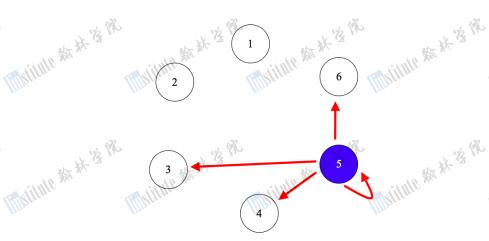
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b. The places where the ambulance locate that cover most zones

appendix; input $A_k = A_5$; input Pop = Pop) It is that when we locate the ambulance in **Zone 5**, the number of people covered Zone 5, the number of people covered maximize. There are 110,000 people covered. When there's a call, the ambulance should go like what the following picture shows.



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4.4.2 Conclusion

Just like model ? Just like model 2, we further discussed the model how we determine the location of *m* ambulances in an area which is divided into *n* zones. At the same that out 2 situations: regardless of the travel time in a zone or considering the travel time in a zone. In the situations of 'Regardless of the travel time in a zone', we have further brithle ## # 18 discussed the two solutions to cost least money and fuel or to cover maximum people. Myithin Mar 14 '8 Also, in the situation of 'Considering the travel time in a zone', we have explored the two solutions to cover most zones or people and give out different results.

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4.5 Testing for the model

We prove that our model is correct via some examples.

4.5.1 Variables

	Variables	Description	
S A MARKET	A_{10}	A matrix which describes the average times among the 8 famous location	法外
Mistime &	$A_{i,i}$	A matrix with simplified information based on A ₁₁ which marks the number larger than '10' as '0' and the rest as '1' so that '1' means that the ambulances can reach the place within 10 minutes	130 130

Shanghai is an international metropolis. We choose 8 famous location from the center of Shanghai and estimate the average time from one location to the center of the standard suitable starting point where the 3 ambulances are located.

Maritule Mark 18 180

Dim Zone 1 as Xu Jia Hui

Dim Zone 2 as The Bund

Dim Zone 3 as West Shanghai Station

Dim Zone 4 as Jing'an Temple

Dim Zone 5 as Hongkou stadium

Dim Zone 6 as Shanghai Circus Stage

Dim Zone 7 as Zhongshan Park

Dim Zone 8 as Wujiao Court Militate Markets

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$$A_{10} = \begin{pmatrix} 1 & 40 & 17 & 9 & 22 & 20 & 11 & 26 \\ 40 & 4 & 18 & 8 & 13 & 13 & 13 & 16 \\ 17 & 18 & 0.5 & 12 & 18 & 12 & 11 & 19 \\ 9 & 8 & 12 & 1 & 15 & 12 & 8 & 18 \\ 22 & 13 & 18 & 15 & 2 & 9 & 21 & 9 \\ 20 & 13 & 12 & 12 & 9 & 1 & 16 & 10 \\ 11 & 13 & 11 & 8 & 21 & 16 & 2 & 21 \\ 26 & 16 & 19 & 18 & 9 & 10 & 21 & 4 \end{pmatrix} A_{11} = \begin{pmatrix} 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 \end{pmatrix}$$

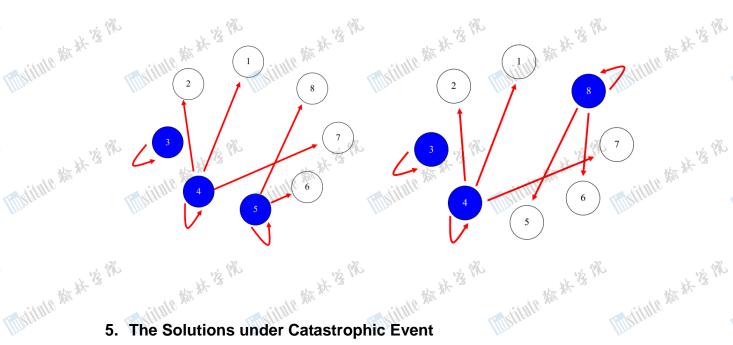
Missiante Mar At 13 182 Through programming we can draw the conclusion. ('Program solution_cover' is in the appendix; input $A_k = A_{11}$, input $Pop = (1085 \ 300 \ 1130 \ 349 \ 792 \ 707 \ 690 \ 1313))$

Stitute the the 's We get the result that when the 3 ambulances are located at Zone 3, Zone 4, Zone 5 or Zone 3, Zone 4, Zone 8, all the zones can be covered. So, our model can be used in the real situation and has a good feasibility.

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Military & St. 18 C. S. Myithin M M 3 Milital Mar 3 Mylithe My XX 3 Mystute Aft FF '3 Team #4170 Page 22 of 30



5. The Solutions under Catastrophic Event

Considering that a serious disaster happen, a lot of unexpected situations appear. The roads may be destroyed so that ambulances would be delayed. The numbers of the regions' importance. So there are a lot of things we cannot predict. Considering these things, we simulate the situation and improve our model. Maritude *** **

5.1 Variables

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7	Variables	Description	.90
ل الله	M	A matrix with each weight of each region in terms of the regions'	17 13 M
* ** Total Olution	M	importance	Z W
Mylithe	A_8	The Average travel time from one city/county to another	
		A matrix with simplified information based on A ₈ which marks the number	
	A_9	larger than '150' as '0' and the rest as '1' so that '1' means that the	😘
ALT WAY		ambulances can reach the place within 150 minutes	- XX- B3
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5.2 Model

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$$\max \sum_{k=1}^{n} m_{k} y_{k} r_{k}$$

$$\begin{cases} y_{k} = \begin{cases} 0, & s_{k} = 0 \\ 1, & s_{k} \ge 1 \end{cases} \\ s_{k} = \sum_{i=1}^{m} s(v_{a_{i}} v_{k}) \\ v_{a_{i}} \in \{1, 2, 3, \dots, n\}, & i \in \{1, 2, 3, \dots, m\} \\ s(v_{a_{i}}, v_{k}) \in A_{8} \\ v_{a_{i}} \neq v_{a_{2}} \neq \dots \neq v_{a_{m}} \\ r_{k} \in B, m_{k} \in \{\underline{m}_{k}, \overline{m}_{k}\}, k \in \{1, 2, 3, \dots, n\} \end{cases}$$

 \underline{m}_k means the min weight which is given out. \overline{m}_k means the max weight which is given out. Matitude Mar At 13 1980

5.3 Example

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To solve the forth question better, we turned the problem into a realistic example to Just like the process we solve Problem 1, 2, 3, we have to give out matrixes like A_2 , Pop . So we chose 8 cities/counties road: Maritute & **

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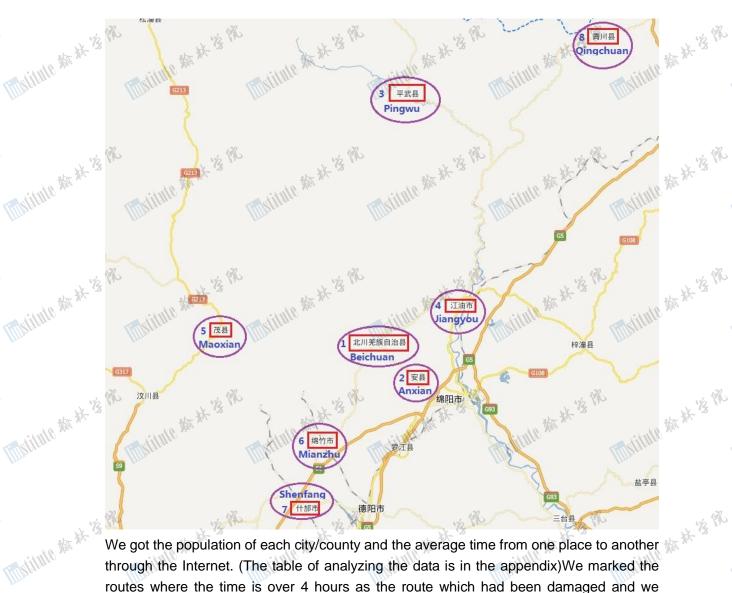
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We got the population of each city/county and the average time from one place to another through the Internet. (The table of analyzing the data is in the routes where the time is over 4 hours as the route which had been damaged and we deleted these routes. And then we got the following matrix.

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$$A_8 = \begin{pmatrix} 47 & \infty & \infty & \infty & 193 & 116 & 146 & \infty \\ \infty & 34 & \infty & 74 & \infty & 66 & 76 & 194 \\ \infty & \infty & 77 & \infty & \infty & \infty & \infty & 227 \\ \infty & 74 & \infty & 52 & \infty & 94 & 103 & 172 \\ 193 & \infty & \infty & \infty & 62 & \infty & 223 & \infty \\ 116 & 66 & \infty & 94 & \infty & 35 & \infty & 225 \\ 146 & 76 & \infty & 103 & 223 & \infty & 29 & \infty \\ \infty & 194 & 227 & 172 & \infty & 225 & \infty & 56 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

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Maritule # # 13 PR To sum up, we got the two matrix and information just like those of question 1, 2, 3. regions. the average injured people of the 8 After that, worked out solution_disaster' is in the appendix; input $M_k=\begin{pmatrix}1&1&2&1&1&2&2&1\end{pmatrix}$; input $A_k=A_9$; input $Pop=\begin{pmatrix}161&500&186&310&90&520&422&1\end{pmatrix}$ $people = \frac{All \quad the \quad injured}{}$

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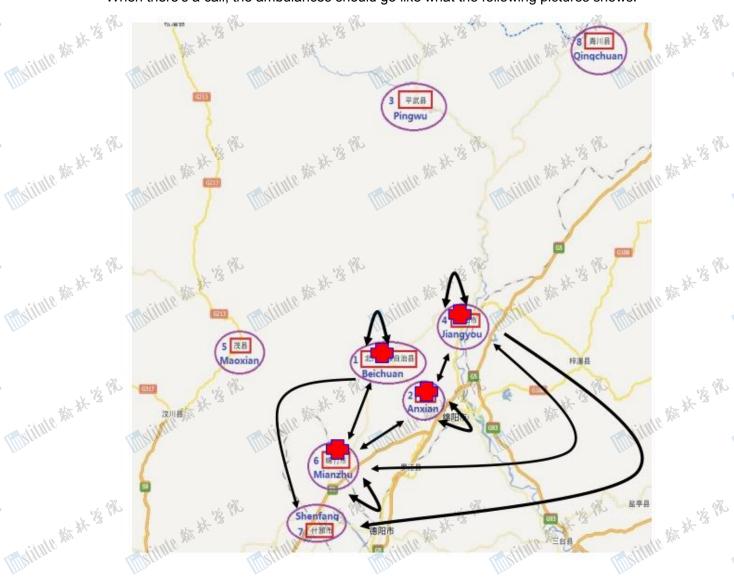
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Military & St. 18 C. S. Mylitute star 3 Mythite Man 34 3 Mystute Aft FF '3 Team #4170 Page 25 of 30

ambulances are mostly in Place 1, 2, 4, 6, the people covered maximize and the

But there exists disadvantages. First, there are less people in the most serious stricken area. Second, maybe some places cannot be reached because of Maritha Art '3 roads.

When there's a call, the ambulances should go like what the following pictures shows.



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We build a simple model to solve the first problem. In the process, we gradually develop the model and build our final model. Furthermore, we test our final model. Shanghai and the results are an income. the model and build our final model. Furthermore, we test our final model via the map of Shanghai and the results are perfect. To solve the forth problem we take the map of via the map of Shanghai and the results are perfect. via the map of Si Chuan Province and the simulation result is that most of the stricken covered. areas can be covered, but some roads are damaged so that several places cannot be 加加拉加

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7. Appendix

a. solution initial

Maritude Mar 14 13 In Matrix C, each row means each solution. The first six columns means the numbers of ambulances that cover this area. The last three columns of C means the location of the 3 ambulances. In Matrix D, each row means the sum number of the zones covered. In Matrix P, each row means the sum number of the people covered by each ambulance.

And \max_{P} means the maximum of each element in P. Most importantly, every row of each matrix means a section Mytitute And At 13 each matrix means a certain solution.

Here's the code:

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```
function [C,D, Cp, p, max_p] = solution_initial(Ak)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Marith Mar ph 18 198
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                                                                                                                       points = 6;
                                                                                                                        selected = 3;
                                                                                                                       RowNum = nchoosek(points, selected);
                                                                                                                       ColNum = points + selected;
                                                                                                                        C=zeros (RowNum, ColNum);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Marithe Mar H. 13 PR
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Maritute & 13
                                                                                                                      Cp = zeros(RowNum, points);
p=zeros(RowNum, 1);
for i=1:points
                                                                                                                                                   m=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Misitate Mark if the
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     Marithte Mark if the
Misitalle Mark 12 182
                                                                                                                                                   for j=1:4
                                                                                                                                                                                 for k=j+1:5
                                                                                                                                                                                                            for 1=k+1:6
                                                                                                                                                                                                                                  C(m,i) = Ak(j,i) + Ak(k,i) + Ak(l,i);
                                                                                                                                                                                                                                                                    C(m,7) = \dot{j};
                                                                                                                                                                                                                                                                    C(m, 8) = k;
Misitate Mark to 180
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                                                                                                                                                                                                                                                                    C(m, 9) = 1;
                                                                                                                                                                                                                                 m=m+1;
                                                                                                                                                                                    end
                                                                                                                                                             end
                                                                                                                                                   end
                                                                                                                       end
                                                                                                                                                                                                                                                                                                                                                                                                                                          Misitale Mark is fix
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                                                                                                                                             D(i,1) = D(i,1) + 1;
end
end
                                                                                                                        for i=1:RowNum
 Misitate At '3
                                                                                                                                                   end
This into the second
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Misitate Mark to the
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                                                                                                                                                   Cp(:,1) = C(:,1) *50;
                                                                                                                                                   Cp(:,2)=C(:,2)*80;
```

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```
Cp(:,3)=C(:,3)*30;
Cp(:,4)=C(:,4)**
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Misitale Mark is 182
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 Marithin 教育 林· 溪 序
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                                                                                                                                                                       , 35;

L(:,5)=C(:,5)*35;

Cp(:,6)=C(:,6)*20;

for i=1:20
                                                                                                                                                                                                                    for j=1:6
     Millitation of the state of the
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Milling Mar H. 18 198.
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Maritule Mar # 18 180
                                                                                                                                                                                                                                                   p(i) = p(i) + Cp(i,j);
                                                                                                                                                 max_p = max(p);
```

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In Matrix C, each row means each solution. In Matrix D, each row means the sum number of the zones covered. In Matrix S leach row means the sum ambulances. In Matrix P, each row means the sum number of the people covered by importantly, every row of each matrix means a certain solution. Here's the code: function [C,D, Cn.s]each ambulance. And \max_{P} means the maximum of each element in P. Most

```
function [C,D, Cp,S, p,max_p] = solution_cover(points,locations,Ak,Pop)
                                                           clc;
                                                           X=[1:points];
len = size(S);
RowNum = nchc
                                                                                                                                                                                                                                                                                     Maritule of the State of the St
                                                                                                                                                                                                                                                                                                                                                          Millinin Art Art 18 PR
                                                           S = combntns(X, locations);
                                                                                                                                                                                                                Maritule Mark is 180
                                                           RowNum = nchoosek(points,locations);
                                                           C=zeros(RowNum, points);
                                                           D=zeros(RowNum, 1);
p = zeros(RowNum, for i = 1: len(1) for j = 3
                                                           Cp = zeros(RowNum, 1);
                                                                                                                                                                                                                                                                                     Marithus 教教教·安风
                                                                                                                                                                                                                                                                                                                                                          Marithin 教教教·蒙然
                                                           p = zeros(RowNum, 1);
                                                                    r i = 1: len(1)

for j = 1:len(2)

C(i,:) = C(i,:) + Ak(S(i,j),:);
                                                           end
                                                                                                                                                                                                                                                                                      加州加州海州
                                                                                                                                                                                                                                                                                                                                                          Maritule # # 18 18
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                                                                      D(i, k) > 0

D(i, 1) = D(i, 1) + 1;

end

end
                                                           for i=1:RowNum
 Misitate At '3
 end

for i = 1: points

Cp(:,i) \rightarrow \cdot
                                                                        end
                                                                                                                                                                                                                                                                                     Marithle Mark if the
                                                                                                                                                                                                                                                                                                                                                          Marithle Market is the
                                                                                                                                                                                                                Misitate # # 18
                                                                       - . points
Cp(:,i)=C(:,i)*Pop(i);
```

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```
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                                                                              matitute 赫 珠 · 溪 [%
                                      Mortifule ## # 13 18
                                                                                                 Milital Mark 18 182
                end
Misiture was by 18
                for i=1:RowNum
                   for j=1:points
                            p(i) = p(i) + Cp(i,j);
                    end
                                                                               Maithin Mark 18 18
                                                                                                   Mitate At 18 18
                                                          Marithus Mar # 18 180
                                         within the the is the
                end
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                max_p = max(p);
```

c. solution_disaster

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In Matrix C, each row means each solution. In Matrix D, each row means the sum number of the zones covered. In Matrix S, each row means the location of the each ambulance. And \max_{P} means the maximum of each element in P. Most importantly every row of and Milital Market 18 importantly, every row of each matrix means a certain solution.

Here's the code:

```
-unc
cle;
v
                                                   function [C,D, Cp,S, p,max p] = solution disaster(points,locations,Ak,Pop,Mk)
                                                                                                                                                                                                                                                                                                                Militing 素素 ·養 序》
                                                                                                                                                                                       Mariante Mar # 13 1980
                                                                                                                                                                                                                                                   Milital Mark 13 190
                                                   X=[1:points];
                                                   S = combntns(X, locations);
                                                   len = size(S);
D=zeros(RowNum,poin

D=zeros(RowNum,1);

Cp = zeros(RowNum,1)
                                                   RowNum = nchoosek(points, locations);
                                                                                                                                                                                                                                                                                                                Marithle And At 13 182
                                                                                                                                                                                       Maritule of the state of the st
                                                                                                                                                                                                                                                    Marithus Market & PR
                                                   C=zeros(RowNum, points);
                                                   Cp = zeros(RowNum,1);
                                                   p = zeros(RowNum, 1);
                                                   for i = 1: len(1)
                                                               for j = 1:len(2)
                                                                                                                                                                                       Ministate the state of the
                                                                                                                                                                                                                                                    Marithus 教教教·後然
                                                                                                                                                                                                                                                                                                                Marithin 教教教·蒙然
                                                                           C(i,:) = C(i,:) + Ak(S(i,j),:);
Mylithe state is
                                                   end
                                                   for i=1:RowNum
                                                               for k =1:points
                                                               if C(i,k)>0
Misitale Mark is fix
                                                                                                                                                                                       Maritule # # 18
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                                                                                                                                  slittile ## # '$ PR
                                                                           D(i,1) = D(i,1) + 1;
                                                               end
                                                               end
                                                   end
                                                   for i = 1: points
                                                               Cp(:,i) = C(:,i) * Pop(i) * Mk(i);
end this think the second
                                                                                                                                                                                      Misitate Mi kit is the
                                                                                                                                                                                                                                                                                                                Marithle Market is the
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                                                   for i=1:RowNum
```

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```
for j=1:points p(i)-
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                                    加加加加州
                                                加加加加
                 p(i) = p(i) + Cp(i,j);
          max_p = max(p);
```

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	City	number	number	population	rate	injured	The state of the s	
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						number		
14	1Beichuan	8605	9693	161000	11.37%	18298	Z.	柳水場
13	2Anxian 💥	3 1571	13476	500000	3.01%	15047		13
The Said	3Pingwu	1546	32145	186073	18.11%	33691		1992 X
nithte state 's	4Jiangyou	394	10006	310000	3. 35%	10400	and the	
	5Maoxian	3122	8183	90956	12.43%	11305	Illins	
	6Mianzhu	11101	36822	520000	9.22%	47923		
	7Shenfang	5924	31990	430000	8.82%	37914		
	ු 8Qingchuan	4663	15390 🚙	250000	_{.02} 8. 02%	20053	A32	
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MEMORANDUM

Maritule Market of PR

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Mistatte Am Ak '3 From: the Ambulance Coordinating Interest Group

To: ESC

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stitute state

Date: 17/11/2013

Subject: Our recommendations from our model and analysis finding

As members of an ambulance coordinating interest group, we are interested in your coordination of the medical ambulances.

Our team develops a simple model to place the three ambulances at the most efficient locations. And we work out the best solutions to locate the 3 ambulances under semi-perfect conditions regardless of the cost times in a zone but considering the cost of travel times in a zone.

Then, we further discuss the model on how we determine the location of m ambulances in an area which is divided into n zones, where m and n stand for not only 3 ambulances and 6 zones but any integer. So we substitute *m*, *n* for our new model.

Although the three ambulances might be enough to cover the whole county, but we do recommend that you increase the number of ambulances because of the uncertain factors that might affect different situations. Therefore, we developed this model to help you decide how to put more of ambulances in the county.

Based on the development of technology, we suggest that you can improve the efficiency of the engines in your ambulances to shorten the time of rescuing.

We also find that when natural disasters occur, the three ambulances will not be able to save most people in time. If the only way between the two counties collapsed in such disasters, more time will be wasted for making a detour or waiting for the cleaning of the obstacles on the road. Therefore, we recommend that you should leave at least three medical helicopters for saving people who live far away from the center of the county. Earthwork cars are also important for cleaning the obstacles on the road which landslides.

Your consideration of this suggestion would be highly appreciated.

We are looking forward to seeing more people saved in disasters and difficult situations in Molitule of the State of the St Maithle Mark 's Ph stitute the sky is the Stitute to the State of the Sta Antitute state 18 18 加油排業學