Problem Chosen	2022 ShuWei Cup Summary Sheet	Team Control Number
B		2022111013803

Summary

With the increasing development of The Times, the war also changed, the continuous improvement of military knowledge reserves, the continuous improvement of military equipment, military planning is increasingly complete, makes the war more reasonable planning before war, this paper is based on a red and blue combat background for its planning and strategic planning, using a variety of methods, has reference significance.

For problem 1, this paper solves it through the site selection model and the force deployment model. In site selection model, first for the overall data and information for visualization and numerical quantification, and then through the **elbow method** optimization k value **k-means clustering algorithm**, get 3 cluster group, in the center of gravity method, calculate the ideal center point, and in the cluster group nearest the actual point as the ideal point, and in the **floyd algorithm** to calculate the total path, and the attack difficulty, finally choose the **red side 184** and blue **side 161**. In terms of force deployment, considering multiple factors, the overall force is first calculated according to the distance of the local command point, and then the force forces are refined through many factors.

For problem 2, first of all, for three different materials, have different demand, so set the demand rate, moreover, considering the overall system, the overall goal is the minimum time, and time including loading and transportation time, after establishing objective function restrictions, found that the restrictions for distance, proposed fixed variable value, in the case of assuming demand equal demand rate and mobilize. Finally, considering the **potential attack, the proportion of the overall path and the attacked path into the loss rate and consumption time**, optimize the model to solve and allocate the number of people and vehicles.

For question 3, for the red attack blue defense mode, the first target is established, that is, red wants to reach the blue command and block retreat path as soon as possible, retreat blue wants to retreat point as soon as possible, so according to the figure, for distance and point selection, for blue use **graph theory** to do similar clustering operations, the evacuation plan of each point. At the same time, considering the interruption of communication factors, the **secondary retreat point** is established to adjust the resulting disturbance generated.

Key words: military strategy; cluster analysis; strategic location; Floyd algorithm; multi-objective planning model

Content

1. Introduction

1.1 Background

With the renewal and upgrading of military equipment, the factors influencing the war were gradually diversified and complicated. Therefore, how to carry out efficient arrangement and deployment in the real-time dynamic battlefield has increasingly become an important topic of military science and technology research. This paper takes the simplified war as an example. From static to dynamic, information transmission, material supply, weapons and equipment, and the enemy's military strength are fully considered. According to different circumstances, formulate the corresponding relatively complete military strategies.

1.2 Work

Task 1: According to the given data set, comprehensively considering the attack difficulty, marching distance, weapon range and air defense deployment of the node, the model is established for military configuration and deployment, while determining the best command location and multiple alternative locations.

Task 2: Based on the optimization results of **Task 1**, the optimization model of medical and military supplies distribution and supply for the warring parties. Secondly, consider the potential attack strategy, provide information about the workers and vehicles needed in the process, presented as a chart.

Task 3: Integrate **Task 1** and **Task 2**, in the case of the red side to attack the blue side defense, put forward the attack and retreat strategy for both sides with their respective advantages, set the retreat node of the blue side as [37,140,378], and consider the difference between the retreat plan under the communication situation.

2. Problem analysis

2.1 Data analysis

(1) Summary of Data: Sheet1 in “Annex1: node & link” provides the coordinate positions of different nodes of the Red and the Blue sides, the corresponding attack difficulty of each node, and the distance length between different nodes of sheet2. “Annex2: Parameter of Weapon” provides the military strength of the Red and the Blue sides, as well as the relevant parameters of different weapons.

(2) Missing value handling: This paper then takes the data of "Annex1.xlsx" and uses the panda's library of Python, check the data for missing values. If there are missing values, we can optionally delete the sample or feature with missing values, or the choice is to use the mean to fill in the missing values. After processing the two workbooks in this way, we can see that the data for this problem is not stored In missing, no missing-values handling is required.

(3) Data visualization: Visualizing sheet1 in Attachment 1, as shown in Figure 1, it can be observed that the average attack difficulty of the overall nodes of the red and blue sides is roughly the same, and is difficult and easy to cross-configure.

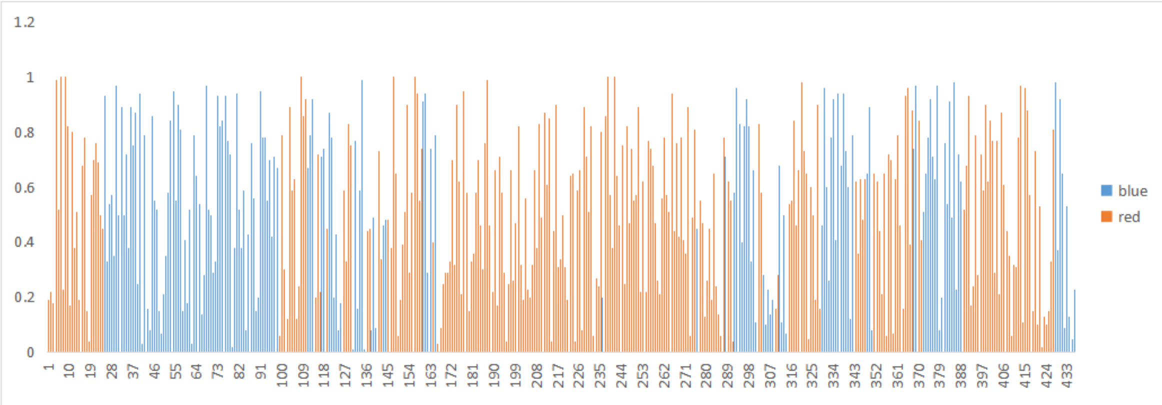

Figure 1 the Red and the Blue Attack difficulty

Figure 2 is the interval visualization of the corresponding overall distance, as shown from the figure, with the most data distributed within 0-1km, with the maximum interval up to 163km.

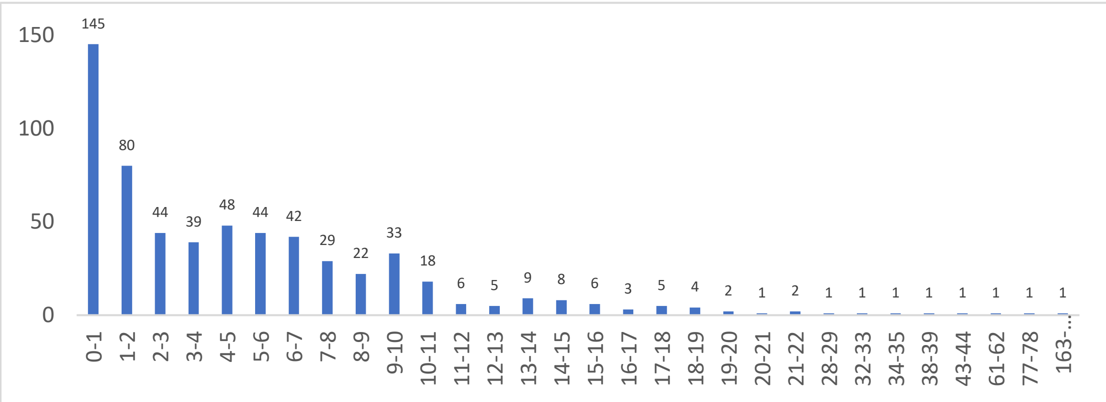

Figure 2 Node grouping

2.2 Analysis of question one

In view of question one, it is required to consider multiple factors to determine the deployment of points, and select the location of the optimal command site. It can be found that the central goal of the problem is site selection and allocation.

First of all, the site selection model is established. In this paper, the following types of site selection factors are considered: the number of surrounding points, the distance of close neighbors, the attack difficulty of itself, and the distance sum between the command point as the overall network center and your own point. Visualize the data as a military network. The k-means clustering method was used for clustering, and the elbow method was used for establishing the k value. After several clusters were obtained, the center of gravity method was used to obtain the ideal point in each cluster group, and the Floyd algorithm was used to calculate the distance between the ideal point and each point in the cluster group one by one, and the smallest one was selected as the backup point. For standby points, the attack difficulty-to-overall distance two-factor model is established to select the most advantage point, that is, the point of the command post.

Make military arrangement for each point, consider: the attack difficulty of the point itself, the distance from the command point, the distance from the enemy point, the attack range of the weapons held, and the range of weapon support. First, the data of each weapon is quantified, and the model is established according to the distance from the command post and the attack difficulty of the point itself to obtain the reasonable total amount of troops at each point. Then, the specific weapon configuration arrangement is considered through the point information. Finally, conduct air defense deployment, consider the UAV damage rate affected by the range of antiaircraft gun, set the antiaircraft point and configuration of UAV.

2.3 Analysis of question two

For question two, the goal is to plan the supply and transportation of materials under potential attacks.

First of all, for three different materials, with different demand, so set the demand rate, moreover, considering the overall system, the overall goal is the minimum time, and time including loading and unloading and transportation time, repeatedly after establishing the objective function restrictions, found that the restrictions for the distance, repeatedly after the fixed variable value, in the case of assuming the demand is the same amount to calculate the demand rate and mobilize. Finally, considering the potential attack, the proportion of the overall path and the attacked path into the loss rate and consumption time, optimize the model to solve and allocate the number of people and vehicles.

2.4 Analysis of question three

Question three for red attack blue defense mode, first to establish the target, namely the red want to reach the blue command as soon as possible and block retreat path, blue want to retreat point as soon as possible, so according to the figure, for the distance and point selection, for blue is using figure theory do similar clustering operation, each point of the evacuation plan. At the same time, it is necessary to consider the communication factors, establish the communication factors, and obtain the optimization results after interfering with the whole.

Finally, drawing the mind map for the thinking framework of the overall text is shown below:

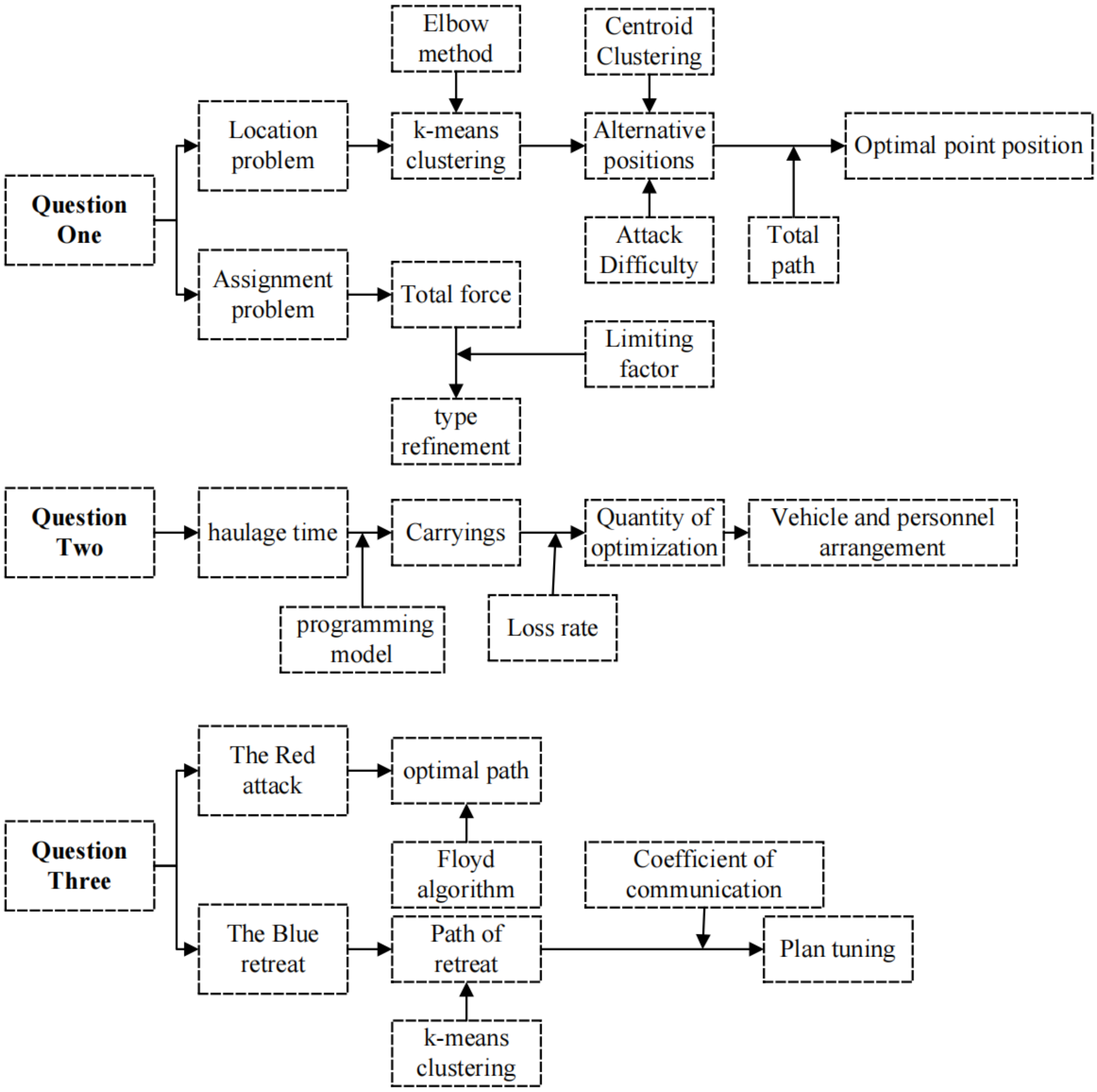

Figure 3 The overall idea map of this article

3. Symbol and Assumptions

3.1 Symbol Description

Symbol	Significance
p_i	Corresponding to different weapon quantization values
N_i	The number of the Red and the Blue sides on their respective weapons
$Total$	The Red and the Blue total force value
d_i	The distance between the corresponding sample node (x_{ix}, x_{iy}) and the k cluster centers
V_i	Troop deployment at each node
L	The sum of the distances between each alternative position location and the other positions
AD	The attack difficulty of the corresponding node
μ_i	Demand rate of each supply material
H_i	Transportation distance of goods
W_i	The amount of goods transported
c	Vehicle speed
P_j	Force value at each point
ζ	Transport loss rate when considering potential attack factors

3.2 Fundamental assumptions

To simplify the given problem and make it more suitable for simulating real life conditions, we propose the following basic assumptions, each of which is reasonable.

• The connections between the points in the model is all connections.

• Suppose that the deployment of each point does not consider the conflict, only the static situation.

• When calculating the loss rate, the ratio of the attacked interval to the total interval is its loss rate.

• Suppose that the transportation process of the cargo is in a stable state except for the potential attacks.

4. Model

4.1 Model establishment and solution of Problem one

(1) Network model setting

First, according to the data set given by the problem setting, the network is modeled, and each data point is turned into scattered points, and the distance is long with weight edge. The figure is as follows:

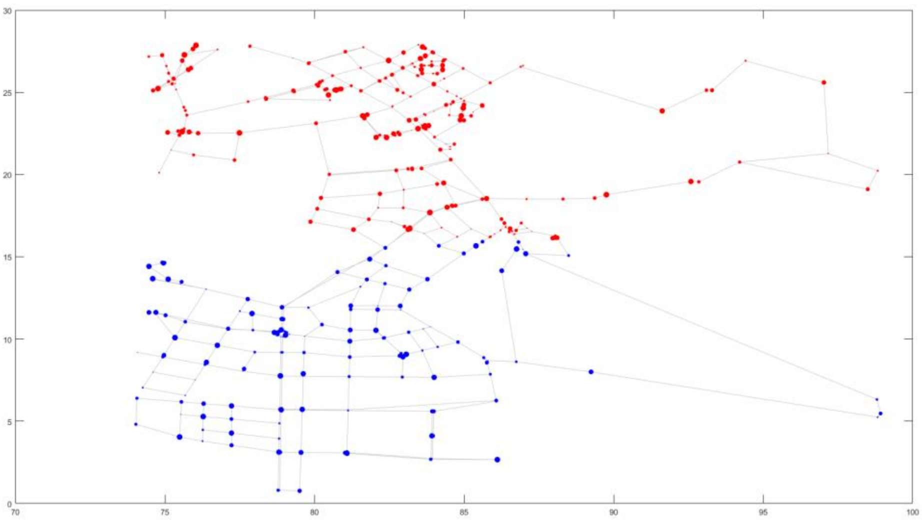

Figure 4: the Red and the Blue assignable nodes

(2) Force quantification

For realistic data processing, each weapon is quantified:

Table 1 Weapon data quantization

Quantify the target	**Quantification value**	heavy tank	100
infantry	5	self-propelled gun	80
light tank	50	bombardment aircraft	100
medium tank	80	antiaircraft gun	100

The calculation formula of the overall military forces on both sides is as follows:

$$Total = \sum_{i=1}^{7} p_i N_i \tag{1}$$

Where p_i is the quantified value, while N_i is the number of weapons.

For the total strength of both sides, the red side is 6874000, and the blue side is 6240600.

4.1.1 Establishment and solution of the site selection model

(1) The k-means cluster takes the alternative clusters

Command post as the central place of the whole war, plays a role of the battlefield integration, consider the point need to be in a surrounding point a greater number of environments, this paper for all points k-means cluster analysis.

The k-means algorithm [4] is a common clustering algorithm, which is a Euclidean distance-based clustering algorithm, which believes that the closer the two targets are, the greater the similarity. The basic algorithm steps mainly cover four steps:

Step1: Select several initialized samples as the initial cluster center $a = a_1, a_2 \dots a_k$.

Step2: For each sample x_i in the dataset, the coordinates (x_{ix}, x_{iy}) are having calculated the distance to the k cluster centers, and classified to the cluster group with the smallest distance. The distance is calculated as follows：

$$d_i = \sqrt{(x_{ix} - a_{xi})^2 + \left(x_{iy} - a_{iy}\right)^2} \tag{2}$$

Step3: For each cluster group, its cluster center is recalculated:

$$a_i = \frac{1}{|c_i|} \sum_{x \in c_i} x \tag{3}$$

Step4: Repeat the second and third steps until the abort condition is reached.

Considering the algorithm optimization, the elbow method and obtain the following result diagram:

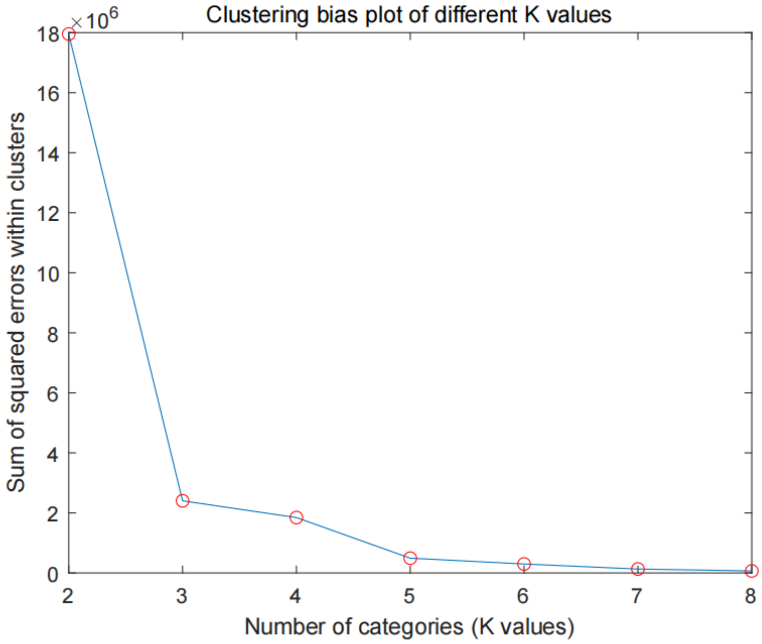

Figure 5 Clustering bias plot of different k values

When k takes 3, the number of clusters is as small as possible and the SSE error value is relatively small, while when the k-SSE value continues to increase, the S S E error value change tends to flatten. Therefore, the initial cluster value is 3. After the cluster value is determined, the overall data is clustered. The results of red and blue division are shown in the following figure:

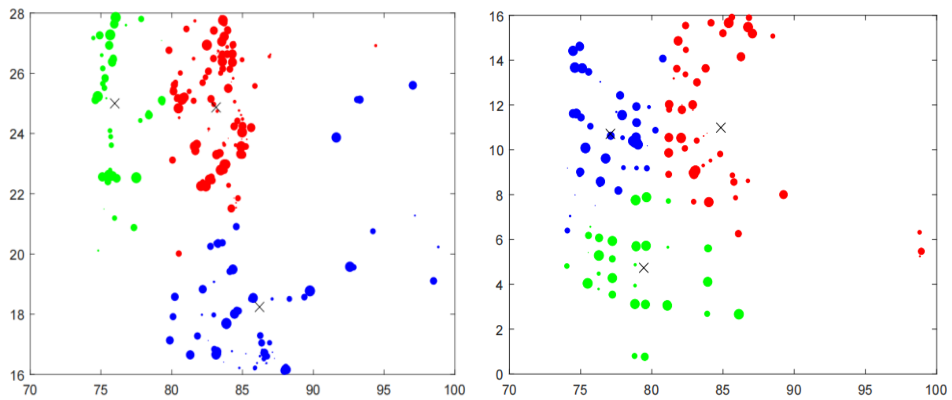

Figure 6 Two-sides clustering result Fig

(2) Cluster center of gravity method proposes alternative points

The center of gravity method is used in each cluster group to find the alternative points.

For the ideal point-point search, the specific search is as follows:

$$\begin{cases} C_x = \dfrac{\sum_{i=1}^{n} D_{ix} V_i}{\sum_{i=1}^{n} V_i} \\ C_y = \dfrac{\sum_{i=1}^{n} D_{iy} V_i}{\sum_{i=1}^{n} V_i} \end{cases} \tag{5}$$

The point coordinates of (C_x, C_y), D_{ix} and D_{iy} are the horizontal and vertical coordinates of the midpoint in the cluster. are the distribution of forces at each point. Here, assuming that the forces are evenly distributed and the total force is Z, and $\sum_{i=1}^{n} V_i = Z$.So the forces at each point can be written in $V_i = \frac{Z}{n}$, so the above ideal point finding formula can be converted into:

$$\begin{cases} C_x = \dfrac{\sum_{i=1}^{n} D_{ix} \frac{Z}{n}}{Z} = \dfrac{\frac{Z}{n} \sum_{i=1}^{n} D_{ix}}{Z} = \dfrac{\sum_{i=1}^{n} D_{ix}}{n} \\ C_y = \dfrac{\sum_{i=1}^{n} D_{iy} \frac{Z}{n}}{Z} = \dfrac{\frac{Z}{n} \sum_{i=1}^{n} D_{iy}}{Z} = \dfrac{\sum_{i=1}^{n} D_{iy}}{n} \end{cases} \tag{6}$$

After obtaining the ideal coordinates, select the nearest point to the ideal point in the cluster group for the alternative point, which can make the close ideal of the point to the maximum extent, that is:

$$\min\left(\sqrt{(C_x - E_x)^2 + \left(C_y - E_y\right)^2}\right) \tag{7}$$

Based on the clustering results, the center of gravity method is used to determine the ideal center point, and the minimum distance between the actual point and the ideal center point between the Red and the Blue points are as follows:

Table 2 Table of alternative points

Point serial number	Camp	The x coordinate of the point	The x coordinate of the point	Attack difficulty
152	Red	88.31	18.51	0.51
184	Red	82.77	25.15	0.70
325	Red	86.25	17.29	0.60
48	Blue	83.64	10.61	0.15
70	Blue	78.85	5.70	0.50
161	Blue	76.75	9.61	0.94

(3) Final point selection

According to the alternative results selected, it can be found that each point is in the center of the cluster to a certain extent. Considering the attack difficulty and the total distance from the point to other points, the total distance should be the smaller, the better. The following evaluation model is established:

$$\begin{cases} L_j = \sum_{i=1}^{n} l_i \ (j = 1,2 \dots k) \\ maxQ_j = maxAD_j \cdot \frac{\sum_{i=1}^{k} L_i}{L_j} \ (j = 1,2 \dots k) \end{cases} \tag{8}$$

L is the sum of the distance between each alternative point and the other point, while AD is the attack difficulty of the point. Therefore, in the Q function, the harder the attack is, the smaller the distance sum, the greater the function value, that is, the better the point point.

Take each point as the starting point by using the Floyd algorithm. Before applying the path algorithm, all the data points are visualized and the weighted undirected graph is drawn, that is, whether each point are connected to each other. The final result is shown as follows:

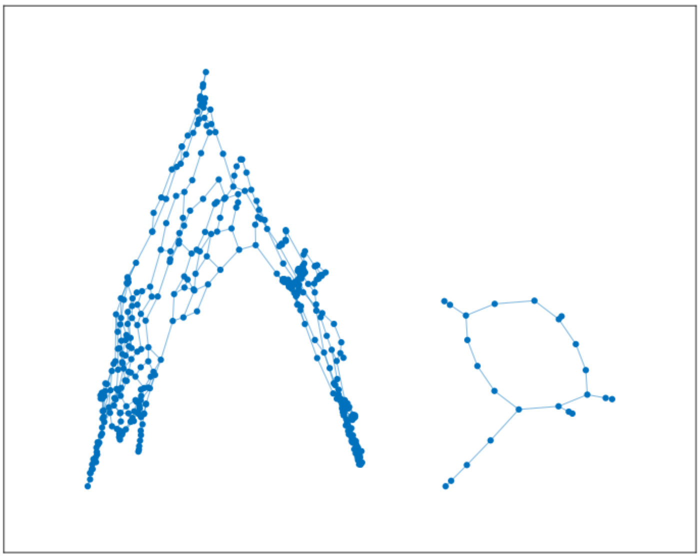

Figure 7 Weighted undirected graph

It can be seen that all the points in this model are not connected to each other.

The final sum of the six points is:

Table 3 Alternative point distance-attack difficulty integration table

Point serial number	Camp	Attack difficulty	Point total distance(km)
152	Red	0.51	15985.58
184	Red	0.70	10062.57
325	Red	0.60	21082.22
48	Blue	0.15	8339.18
70	Blue	0.50	8222.73
161	Blue	0.94	8048.01

Finally, considering the distance and attack difficulty factors, the final command post is red 184 and blue 161, point 184 has the highest attack difficulty and its total distance is significantly small, while point 161 is nearly twice as difficult as the remaining points, while the total distance has the minimum total distance. And red 152 and 325 and blue 48 and 70 as the alternative points.

4.1.2 Establishment and solution of the force allocation model

(1) Scope of attack definition and initial allocation of troops

According to different weapons and types, they have different properties, which makes their respective attack range different. In this paper, we consider the attack circle with its own fixed attack radius, namely its attack range.

Therefore, under the background of the problem, tanks and self-propelled guns, as mobile vehicle weapons, can provide the surrounding fire support in time. Therefore, under the delineation of the attack range, they should be set in the nearest enemy and the optimal support position.

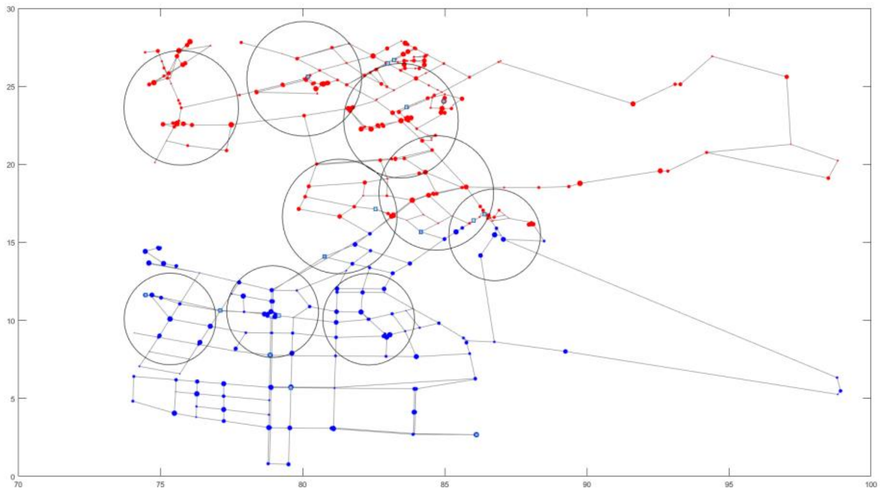

Figure 8 Simulated fire coverage map

The total forces at different points are deployed according to the attack difficulty of the points. The preliminary forces are allocated equally, using excel operation. The results are as follows, showing 20 results, and the rest are in the supporting materials:

Table 4 Schematic diagram of forces distribution at each node

Id	Camp	Attack difficulty	Forces distribution
1	red	0.19	9529.81
2	red	0.22	11034.52
3	red	0.18	9028.24
4	red	0.99	49655.33
5	red	0.52	26081.59
25	blue	0.93	63019.42
26	blue	0.33	22361.73

27	blue	0.54	36591.92
28	blue	0.57	38624.80
29	blue	0.35	23716.99

(2) The loss of the drone

Considering drones vision weapons as aerial combat, it will certainly play an important role in the information transmission, so in this case, you will try to break when the enemy drone invasion, and can defeat the UAV equipment for anti-aircraft guns, anti-aircraft gun range is difficult to quantify, so the range of the given gun, get anti-aircraft range, after literature search, the general range of 6 to 20 km, so given self-propelled gun range and movement range can be used as a reference for anti-aircraft guns.

According to the given data, set the pitch angle: about 2 degrees-65 degrees, the horizontal range of 58 degrees, the maximum strike distance: 17.23km. The anti-aircraft gun attack is not fixed, so the entire maximum attack range is half the sphere, and the ratio of its attack coverage to the whole hemisphere is the loss rate of the drone driving here. The figure below:

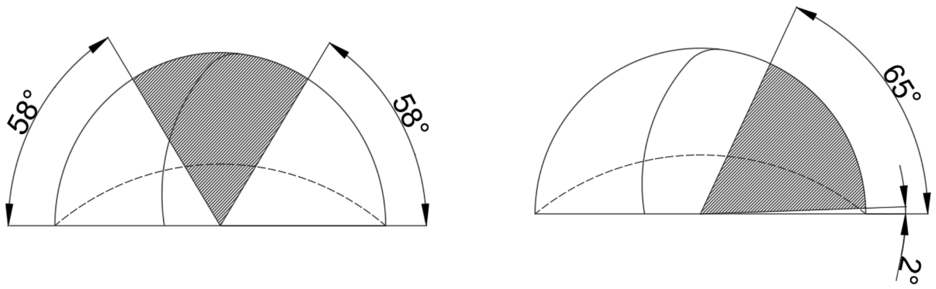

Figure 9 Diagram of different angles

The calculation is as follows:

$$\eta = \frac{V_{attack}}{V_{total}} = 12.4\% \tag{9}$$

That is, after the point loss rate is considered in the direction of the UAV, and the flight path of the UAV, both the UAV and the altitude shoot point against the opposing UAV are arranged at the adjacent enemy point. According to the problem, the main number of the UAV is determined by the attack difficulty of the point, and the greater the attack difficulty, the more the number of UAVs.

(3) Distance optimization equilibrium model building

In terms of the overall force distribution, this paper adopts the equilibrium model starting with the attack difficulty. The more difficult the attack point force allocation is relatively small, and the ultimate goal is to achieve the initial distribution balance, so an optimal target planning model can be preliminarily established. The ultimate goal is to achieve the balance between attack difficulty and force distribution, where the variance is as close as 0.

$$\begin{cases} \mathrm{D}\big(f(x)\big) \approx 0 \\ f(x) = AD_i P_i \end{cases} \tag{10}$$

P_i is the number of troops deployed at each point, and the main limitation factor is that the sum of the forces needs to establish the value, namely:

$$\sum_{i=1}^{n} P_i = Total \tag{11}$$

Comprehensive writing:

$$\begin{cases} \sum_{i=1}^{n} P_i = Total \\ f(x) = AD_i P_i \\ \mathrm{D}\big(f(x)\big) \approx 0 \end{cases} \tag{12}$$

(4) Distance tuning based on the same command post

Based to the actual situation, the total allocation of troops can be determined by the difficulty of point attack, but the actual allocation needs to adapt to the situation of each weapon, so this paper sets different configuration of different weapons. The weapons are prioritized as follows: Antiaircraft guns> Heavy tanks> heavy tanks> Light tanks> Self-propelled artillery> infantry.

For anti-aircraft guns, it is necessary to set ten anti-aircraft points. Because the anti-aircraft point works on the UAV, so the nearest point to the enemy is considered, and when the point with excessive boundary is removed. Fit the next type:

$$A_i \propto \frac{L_{2i}}{L_{1i}} \tag{13}$$

L_{1i} is the distance between the point and the enemy point, and L_{2i} is the distance from the command point.

After calculating the wired distance from the command ground of the other side, the anti-aircraft gun points of both sides are established, and finally the red side is [141,151,157,158,269,389,391,395,396,397], meanwhile, the final choice of the blue side is [276,292,293,294,296,307,331,349,350,378].

For the tank, considering the distance between its point and the enemy command post, the smaller the distance, the more the number of arrangements, and the smaller the distance, the larger the size of the arranged tank is, and the different models of the tank have a running distance, considering that it can be as close to the enemy point as possible.

According to the point and the distance of the enemy command calculation and sorting, and do the following figure, you can see the distance with the enemy are gradient and cliff growth trend, so in the lowest point of more tanks, for blue, visible blue and red headquarters before the distance of the cliff before 86 points, so in arranging tanks in this point, also have 59 for red 19 points.

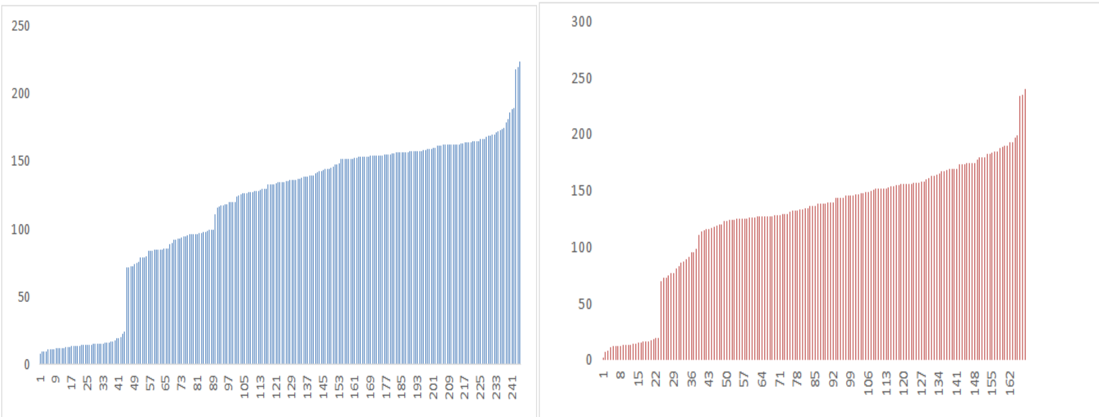

Figure 10 the Red and the blue distance from the other side's command ground

Therefore, in the initially selected points of the tank, according to the distance, the attack difficulty of the point and the support mileage of the tank itself, the parts of the selected points are shown as follows:

Table 5 Tank and UAV deployment status

ID	Distance from the enemy command office	Heavy tank	medium tank	Small tank	UAV
292	69.7706	20	0	0	15
331	70.2442	20	0	0	15
61	100.9646	0	20	0	10
50	101.517	0	20	0	10
84	125.2514	0	10	10	5
52	125.544	0	0	20	5
85	125.547	0	0	20	5

For the self-propelled guns and infantry, the self-propelled guns are configured as evenly distributed as possible, while the infantry are inserted as the final adjustment parameters.

Due to the strong support and firepower capability of the self-propelled artillery, they are evenly distributed, and the infantry is included in the deployment plan as a supplement, and the final situation is shown as follows:

Table 6 Final deployment situation is part of the data table

ID	Distance from the enemy command office	Heavy tank	medium tank	Small tank	UAV	self-propelled gun	infantry
292	69.7706	20	0	0	15	83	6132
331	70.2442	20	0	0	15	85	6371
61	100.9646	0	20	0	10	80	5447
50	101.517	0	20	0	10	83	7198
84	125.2514	0	10	10	5	85	6376
52	125.544	0	0	20	5	84	6315
85	125.547	0	0	20	5	84	9298

4.2 Model establishment and solution of Problem two

4.2.1 Supplies supply transport model

In the supply model, this article considers the command post point as the starting point, and each point as the receiving point. According to the literature, three cargo transport supply models are established: **chain supply model, converged supply model, and hierarchical supply model are established**. The three models are shown as follows:

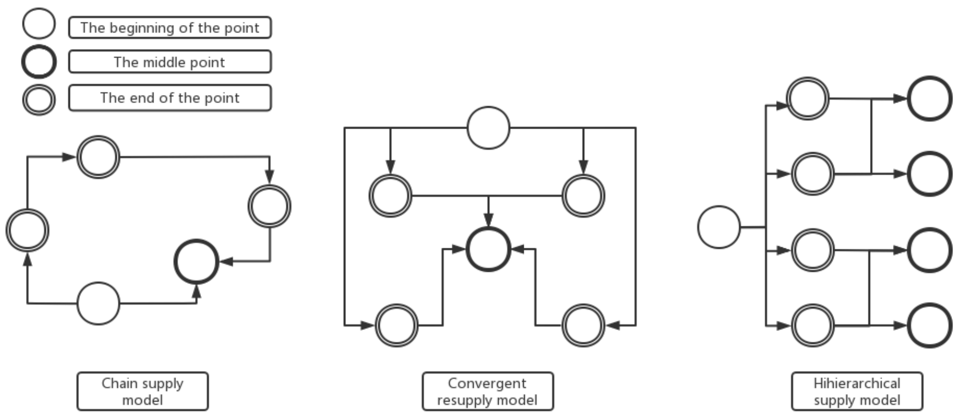

Figure 11: Flow chart of the supply model

Chain supply model: starting from the starting point (command post), directly delivered to the destination point or join the intermediate stay point and sent to the final destination point.

Convergent supply model: transport goods from each intermediate point to each point through the starting point.

Hierarchical supply model: reach the primary middle point through the starting point, and then send the respective primary middle point to the respective target point.

Different supply models have their own advantages and disadvantages. However, due to the military material supply in this paper, the differences of the three models are concentrated at the same points and the quantitative movement of materials. Therefore, this paper establishes a planning model based on the chain supply model.

For the three different supplies, the demand is different $\mu_i(i = 1,2,3)$, which indicates the unit force demand rate for medical supplies, military supplies and daily supplies respectively, and the equal distribution of troops at each point is assumed, that is, the force at each point is 25650 and the blue side is 37146 as a preliminary value, and then bring into the actual value.

Considering the whole combat network model as a whole system, in the process of transporting cargo, without considering the potential attack factor, the overall time includes the cargo shipment time, cargo transportation time and cargo unloading time, which is defined as $t_i(i = 1,2,3)$ respectively. For different goods, shipment times were defined as $t_{1i}(i = 1,2,3)$, unloading time as $t_{2i}(i = 1,2,3)$, cargo transport distance as H_i, vehicle speed as c, transport volume as W_i, and number of points as n.

$$\begin{cases} \mathrm{t_1} = \sum_{j=1}^{n}\sum_{i=1}^{3} W_i \mathrm{t_{1i}} = \sum_{j=1}^{n}\sum_{i=1}^{3} \mathrm{P_j \mu_i t_{1i}} \\ \mathrm{t_2} = \frac{H_i}{\mathrm{c}} \\ \mathrm{t_3} = \sum_{j=1}^{n}\sum_{i=1}^{3} W_i \mathrm{t_{2i}} = \sum_{j=1}^{n}\sum_{i=1}^{3} \mathrm{P_j \mu_i t_{2i}} \end{cases}, \tag{14}$$

The objective function is:

$$\begin{aligned} \min\mathrm{T} = \min(\mathrm{t_1} + \mathrm{t_2} + \mathrm{t_3}) &= \min\left(\sum_{j=1}^{n}\sum_{i=1}^{3} \mathrm{P_j \mu_i t_{1i}} + \sum_{j=1}^{n}\sum_{i=1}^{3} \mathrm{P_j \mu_i t_{2i}} + \frac{H_i}{\mathrm{c}}\right) \\ &= \min\left(\sum_{k=1}^{2}\sum_{j=1}^{n}\sum_{i=1}^{3} \mathrm{P_j \mu_i t_{ki}} + \frac{H_i}{\mathrm{c}}\right). \end{aligned} \tag{15}$$

The overall planning function can be written as:

$$s.t\begin{cases}\min\left(\sum_{k=1}^{2}\sum_{j=1}^{n}\sum_{i=1}^{3}\mathrm{P_j\mu_i t_{ki}}+\frac{H_i}{\mathrm{c}}\right)\\ \sum_{i=1}^{n}H_i=H\end{cases}\tag{16}$$

After setting the parameter except $\mu_i(i=1,2,3)$, assume its three inequivalent $\overline{\mu}$, and according to the actual demand of the three-supply demand rate and demand, according to the data query, define the unit goods required workers and vehicles can calculate the final workers and vehicle demand, thus to obtain the supply strategy of the red and blue sides.

4.2.2 The Potential Attack Factor perturbation model

(1) Attack range and impact rate

When considering the potential attack factor, the enemy understands the transportation process and interferes with the vehicle in order to intervene in the delivery of materials, and the impact should be accompanied by whether the path will be truncated. Assuming that the enemy's potential attack impact on us will affect the relevant path at the nearest 50 points to the enemy command ground, and the loss rate is set to ζ. The redundancy of t_0 requires appropriate optimization for the above model, the target time becomes a value of:

$$\begin{aligned}\min\mathrm{T}&=\min(\mathrm{t_1+t_2+t_3+t_0})\\&=\min\left(\sum_{j=1}^{n}\sum_{i=1}^{3}\frac{\mathrm{P_j\,\mu_i}}{1-\zeta}\mathrm{t_{1i}}+\sum_{j=1}^{n}\sum_{i=1}^{3}\frac{\mathrm{P_j\,\mu_i}}{1-\zeta}\mathrm{t_{2i}}+\frac{\mathrm{H_i}}{\mathrm{c}}+\mathrm{t_0}\right)\\&=\min\left(\sum_{k=1}^{2}\sum_{j=1}^{n}\sum_{i=1}^{3}\frac{\mathrm{P_j\,\mu_i}}{1-\zeta_i}\mathrm{t_{ki}}+\frac{\mathrm{H_i}}{\mathrm{c}}+\mathrm{t_0}\right),\end{aligned}\tag{17}$$

The planning function changes to:

$$s.t\begin{cases}\min\left(\sum_{k=1}^{2}\sum_{j=1}^{n}\sum_{i=1}^{3}\frac{\mathrm{P_j\,\mu_i}}{1-\zeta_i}\mathrm{t_{ki}}+\frac{\mathrm{H_i}}{\mathrm{c}}+\mathrm{t_0}\right)\\ \sum_{i=1}^{n}H_i=H\end{cases}.\tag{18}$$

For the definition of ζ, it should be related to the path length within the range of fire. Assuming that the attack radius of an attack point is r, the path length is L_0, and the path vertical direction clip angle is θ, the diagram is as follows:

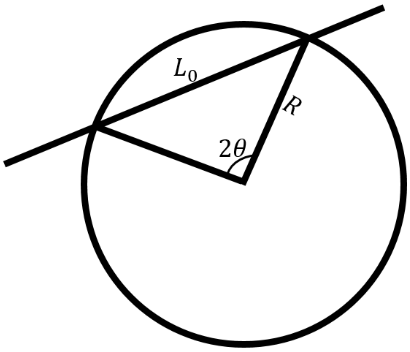

Figure 12 Schematic of the range of fire

Define the loss rate, as the ratio of the length range to the total length of the received attack on the path, namely:

$$\zeta = \frac{2r\sin\theta}{L_0}. \tag{19}$$

(2) Supply strategy optimization results

According to the model solution, the preliminary demand ratio after converting the troops into infantry numbers is formulated as follows：

Table 7 Demand rate reference value table

Demand for medical supplies (kg)	Demand for military supplies (kg)	Demand for Daily material supplies (kg)
0.1*military strength	0.15*military strength	0.15*military strength

When considering the loss rate, the loss rate is calculated by 20% from the nearest point distance from the enemy as the center radius, and from the average path length as the path reference value.

At the same time, after considering the loss rate, the greater impact of the enemy point is increased, partly as follows:

Table 8 Table of loss rate compensation values at some points

ID	Demand for medical supplies (kg)	Demand for military supplies (kg)	Demand for Daily material supplies (kg)
110	1880.67	2821.25	2821.25
100	4669.66	7004.51	7004.51
109	2302.40	3453.60	3453.60
126	2950.97	4426.45	4426.45

127	3794.10	5691.23	5691.23
99	4475.68	5620.33	5620.33

Finally, for the overall transport volume, the defined load of the transport vehicle is 50t / vehicle, which can be obtained. Meanwhile, for workers, each vehicle is equipped with three workers. The comprehensive value is shown in the following table:

Table 9 Number of vehicles and workers' table

Project supplies	medical materials	military materials	daily material	aggregate
Number of red vehicles	140	206	206	552
Number of red workers	420	824	824	1656
Number of blue vehicles	125	188	188	501
Number of blue workers	375	564	564	1503

At the same time, the following diagram of the transportation is shown, and the materials of each point are distributed to the point itself by the command post.

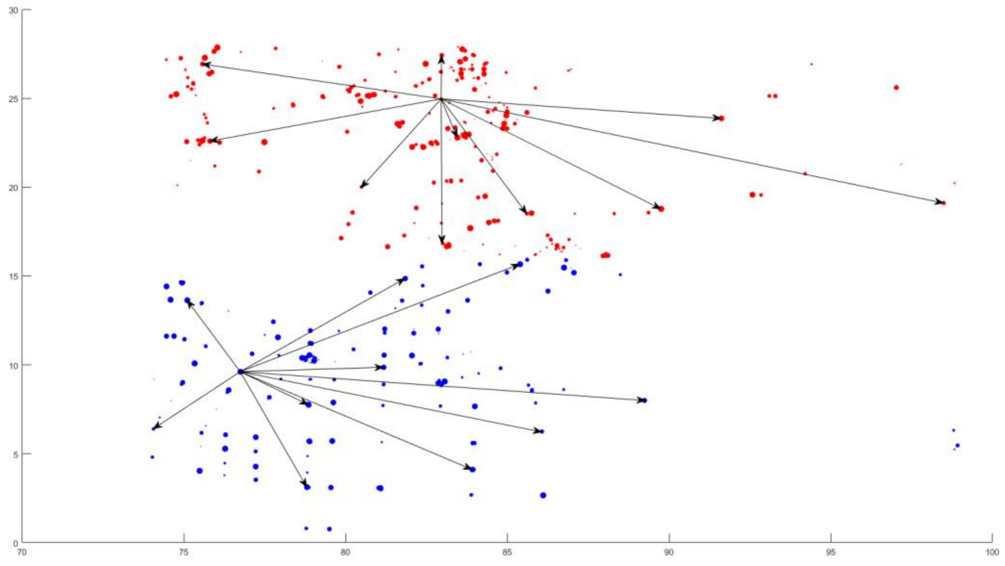

Figure 13 Divergence diagram of material delivery

4.3 Model establishment and solution of Problem three

4.3.1 Red offensive plan

For the attacking side, the target of the Red side should be to reach the blue command point and the blue retreat point as soon as possible. First, establish the minimum time function according to the target, including the distance to the blue command point of each point and the movement speed of each device. Therefore, in this paper, the red side considers the attack target of the blue side, and can use the floyd algorithm to solve the optimal path by graph theory and obtain the optimal solution.

Floyd algorithm

Floyd algorithm is an algorithm that uses the idea of dynamic programming to find the shortest path between multiple source points in a given weighted graph, which can correctly handle the shortest path problem of a directed graph or a directed graph. This algorithm triple loop structure is compact, simple and effective, suitable for multiple source shortest path, efficiency is higher than doing | V | SPFA algorithm, V Dijkstra algorithm is higher than that of execution.

Table 10 Steps of Floyd Algorithm

Steps of Floyd Algorithm	
D（i,j）:	The distance from i to j
R（i,j）:	The subsequent points of i on the current shortest path between i and j enter the weighted proximity matrix A (i, j)
1)	For i = 1 to n do
2)	For j = 1 to n do
3)	D (i, j) ← A (i, j), R (i, j) ← j
4)	For k = 1 to n do
5)	For i = 1 to n do
6)	For j = 1 to n do
7)	If D (i, k) +D (k, j) < D (i, j) then
	D (i, j) ← D (i, k)+D (k, j)
	R (i, j) ← R (i, k)
	end

Through the distance solution, the distance between the retreat point and the command point of the blue side is found out respectively, and the change trend of the distance can be seen from the visual display. The visualization image of the wired distance between the red side and the blue side command points is as follows:

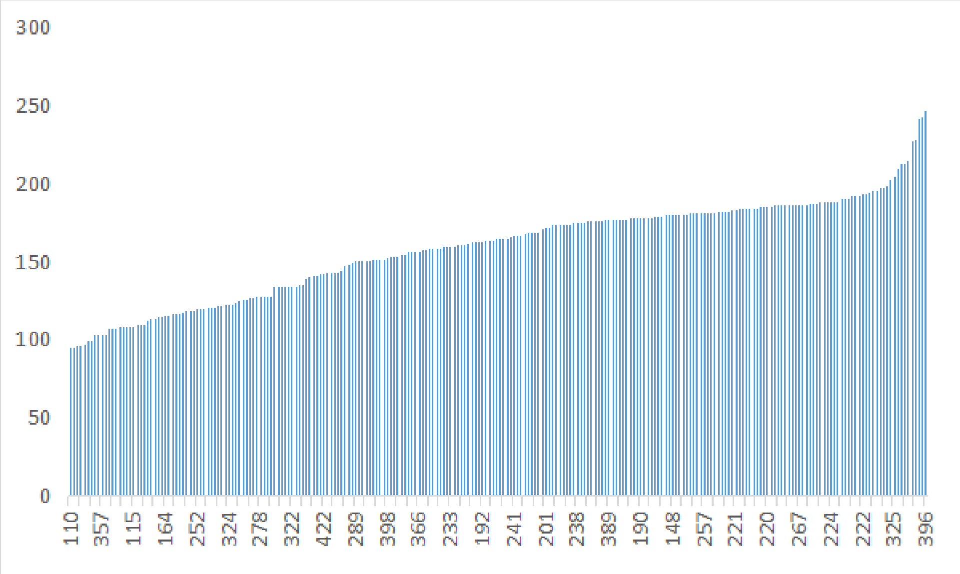

Figure 14 The wired distance of the red side arriving at the blue side command point

Through the distance of the red and blue command show visible, red and blue command of the nearest point is about 100km, according to the principle of military strategy, red point a total of 268, formulate the fixed attack point, to attack blue square 210 points, including 60-point attack command post, 150-point attack three retreat point. And the disconnected points should be removed.

According to the final decision results, the red side's offensive target planning is shown as follows:

Table 11 Red side attack point arrangement

Target point	Offensive point
161	110 100 109 127 126 128 99 356 355 357 108 114 103 107 119 354 129 116 115 104 105 309 353 102 352 255 101 164 250 3 106 153 254 2 256 251 252 166 285 284 253 287 283 281 280 324 277 282 286 343 279 154 351 273 278 291 344 290 347 152
37	274 323 271 322 272 275 270 269 321 155 424 425 422 423 156 420 345 421 346 407 320 289 405 359 401 402 400 404 399 398 213 403 360 358 371 370 408 310 366 365 419 362 363 416 409 232 364 233 327
140	415 235 361 231 414 417 157 192 426 413 410 418 158 193 412 185 411 241 205 184 204 315 427 217 183 201 318 200 317 167 261 182 237 181 238 260 168 246 259 262 219 230 389 328 199 188 170 239 367 263

378	203 190 191 264 265 175 169 174 248 258 245 240 189 266 180 257 215 198 197 212 172 171 173 221 227 229 196 195 211 319 234 220 210 218 202 187 249 209 267 206 223 216 207 208 179 224 178 214 228 225

The attack path is also visualized as follows:

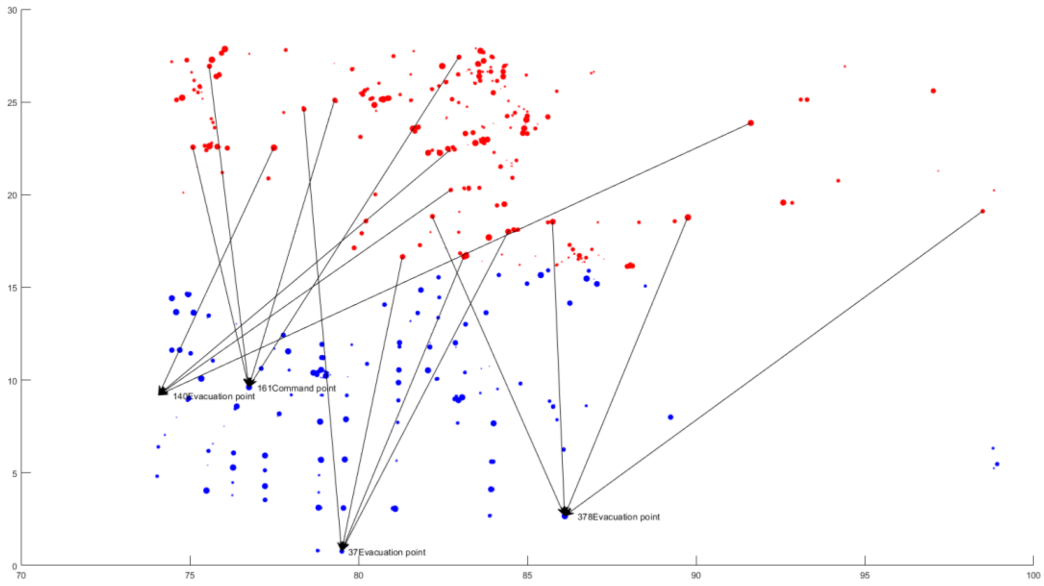

Figure 15 Red side part of the attack point display diagram

4.3.2 Blue retreat plan

For the blue side, it is necessary to be close to three points as soon as possible and evacuate as soon as possible. Therefore, according to the above graph theory algorithm, it can preliminarily obtain the connection distance of the retreat point in the blue side. Therefore, without the case of communication interference, the blue side's retreat plan can be distributed as follows, that is, each point can retreat to different points respectively.

According to the graph theory algorithm, the length is obtained as follows to considering the distance.

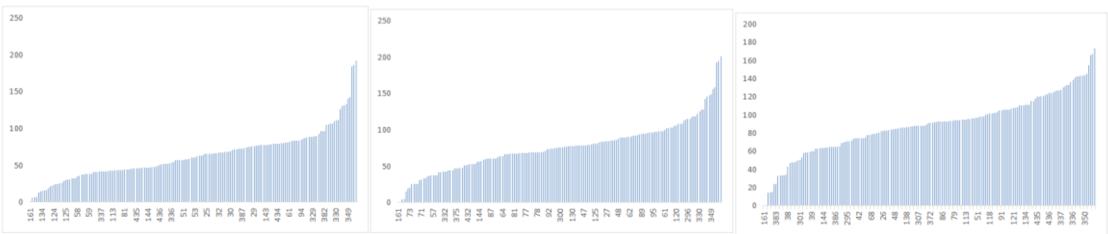

Figure 16 The blue side has the distance from the retreat point

According to the above visual results, the points of the three retreat points are selected, the three points are clustered as the cluster centers, and the clustering results are finally obtained. The same retreat points are like the retreat point, and the specific points of the final retreat plan are as follows:

Table 12 Blue side point retreat plan

Target point	Point location
37	25 26 27 29 30 31 32 33 34 35 36 41 42 43 44 45 46 47 48 49 50 51 51 53 54 58 59 60 61 62 63 64 65 66 67 68 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 111 112 223 117 118 120 121 122 123 124 125 130 131 132 133 134 135 138 139 144 160 162 163 165 236 276 288 292 293 297 298 299 304 305 306 330 331 336 337 338 339 340 341 342 349 350 368 369 435 436
140	38 39 40 55 56 57 69 70 71 72 73 301 332 333 334 372 373 374 375 381 384 385 386 387 428 429 430 431 432 433 434
378	28 143 294 295 296 300 307 308 311 312 313 314 329 335 348 376 377 379 380 382 383 388

And for such an aggregation direction is visualized on the network map, get the following figure, more clearly see the retreat direction.

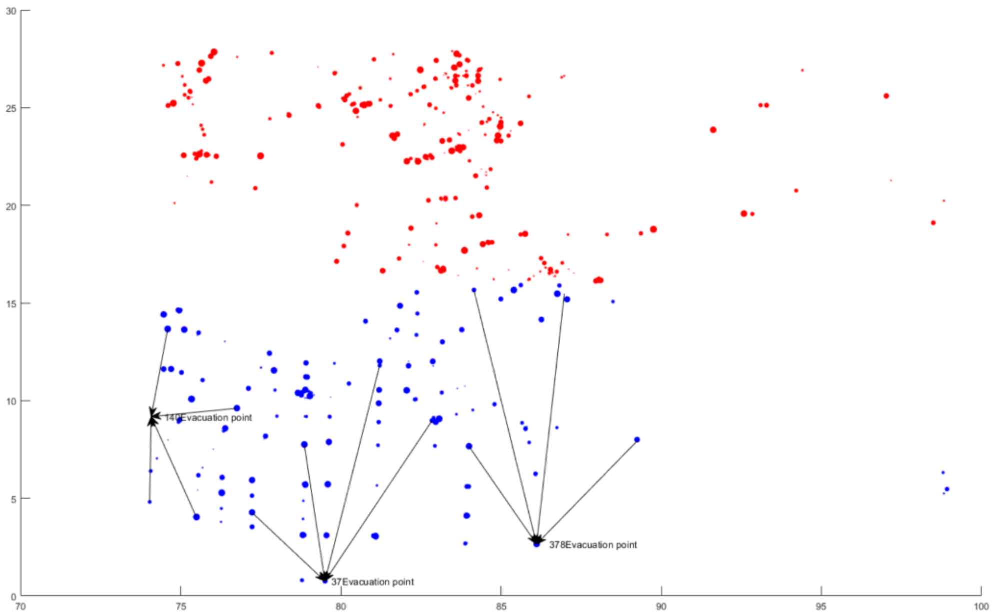

Figure 17 Blue retreat map

Next consider the disturbance of communication, for communication situation, the introduction of communication factors, for each point of different communication factors, communication interruption may lead to information cannot be distributed directly from the command post, so set up a hierarchical structure, information distributed by the command post to the level transfer, and then distributed to each point, the diagram is as follows:

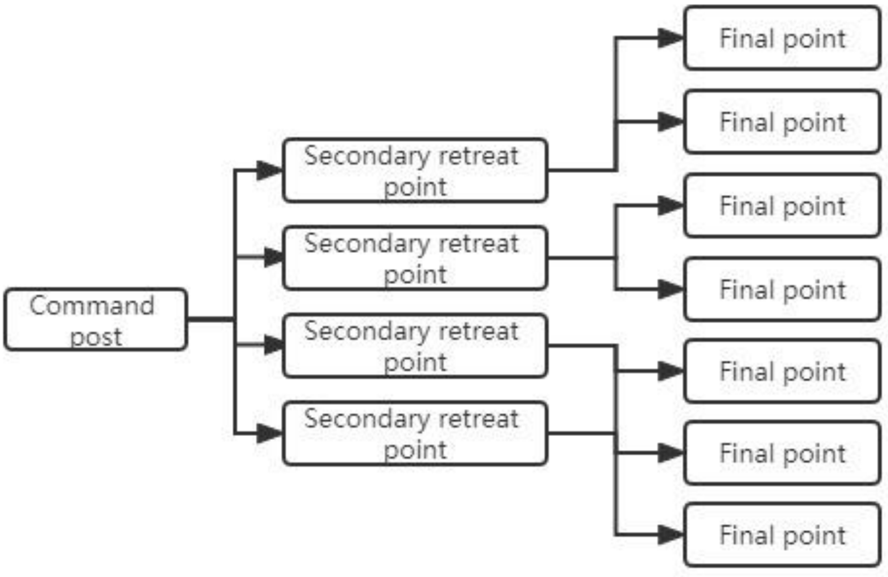

Figure 18 Flow chart of a multilevel retreat plan based on communication damage

According to the distance between each point and the retreat point, considering the distance, 8 points are selected as the secondary retreat point. The selection criterion for selecting the secondary retreat point is that the distance from the retreat point is significantly small, as follows:

Table 13 Selection table of the secondary retreat points

Target point	Secondary retreat points
37	433 434
140	135 139 165
378	379 380 382

After the establishment of the second level point, the rest of the points choose to go to the secondary retreat point or go to the retreat point directly according to their respective distance, which can ensure that the timeliness of the withdrawal can still be guaranteed when the information is interrupted.

The retreat pattern after the establishment of the secondary retreat point is as follows:

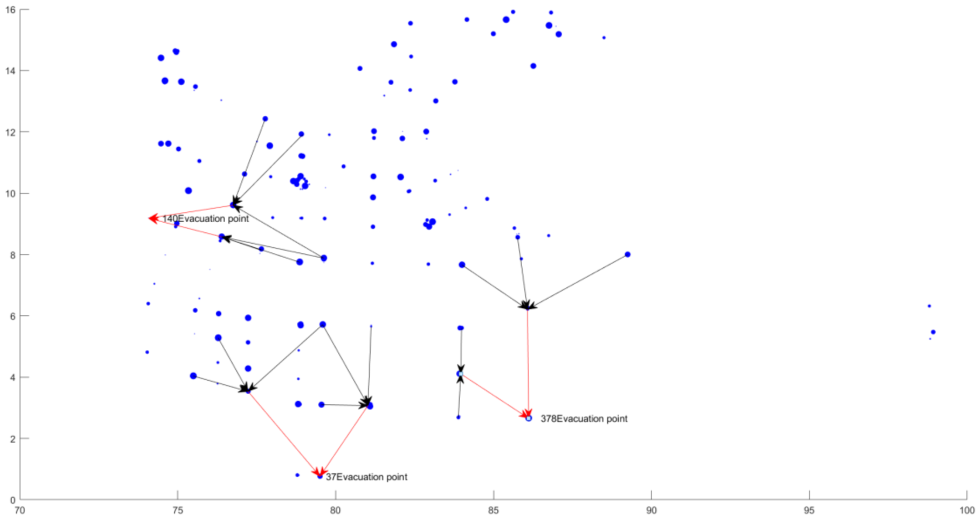

Figure 19 Schematic diagram of secondary retreat retreat plan

5. Strengths and Weakness

5.1 Strengths

(1) The first problem uses the elbow rule to determine the value of k and improve the clustering degree of each cluster. In addition, the use of the barycentric method, which has the characteristics of simple and continuous site selection, for the location of the reserve position is helpful to find the optimal solution of the location problem.

(2) The second problem constructs the objective programming function based on the chain replenishment model, which is simple and clear, and fully considers the time size of different stages of the freight process. In addition, the potential attack factor disturbance model is constructed to dynamically consider the supply situation, which is more consistent with the actual war.

5.2 Weakness

In this paper, the influence factors of military strategy are not fully considered, such as geological factors, vegetation coverage and civil and social factors, which restricts the scope of application of the model to a certain extent. In addition, for the material replenishment model, the replenishment process is simplified, and the actual situation is more complex, so more parameters and conditions can be referred to further optimize the model in the later stage.

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Appendix

1. Question 1 related code

1.1 The Red and the Blue k-means clustering algorithm

```
clc
clear
close all
data1 = xlsread("red_camp.xlsx",1,'A2:F269');
data2 = xlsread("blue_camp.xlsx",1,'A2:F169');
r = zeros(268,3);    % The distance between the red station and the data point
m = [86.20111656250127,18.240745416666616
      83.13515036496499,24.867802676399034
      75.97725245098184,24.99990915032696];    % The red cluster points
for i = 1:268
      for j = 1:3
            r (i, j) = sqrt((data1(i,2) - m(j,1)) ^2 + (data1(i,3) - m(j,2)) ^2);
      end
end
for i = 1:3
      rd(i) = find(r(:,i)==min(r(:,i)));    % Red square station
end

b = zeros(168,3);      % Distance from the blue square site to the data point
n = [79.43385597826244,4.735525362318804
      84.8483611607156,10.989816071428649
      77.08991515151642,10.711474747474709];    % Blue square cluster points
for i = 1:168
      for j = 1:3
            b(i,j) = sqrt((data2(i,2) - n(j,1))^2 + (data2(i,3) - n(j,2))^2);
      end
end
for i = 1:3
      bd(i) = find(b(:,i)==min(b(:,i)));    % Blue square site
end
```

```
for i = 1:268
    if data1(i,6) == 1
        plot(data1(i,2), data1(i,3),’. b’,
            'MarkerSize’, data1(i,5) *25);
    elseif data1(i,6) == 2
        plot(data1(i,2), data1(i,3),'.r',...
            'MarkerSize’, data1(i,5)*25);
    elseif data1(i,6) == 3
        plot(data1(i,2), data1(i,3),’. g’, ...
            'MarkerSize',data1(i,5)*25);
    end
    hold on;
end
plot(m (:1), m(:,2),'xk',...
    'MarkerSize',10);
figure
for i = 1:168
    if data2(i,6) == 1
        plot(data2(i,2), data2(i,3),’. g’, ...
            'MarkerSize’, data2(i,5) *25);
    elseif data2(i,6) == 2
        plot(data2(i,2), data2(i,3),’. r’, ...
            'MarkerSize’, data2(i,5) *25);
    elseif data2(i,6) == 3
        plot(data2(i,2), data2(i,3),’. b’, ...
            'MarkerSize’, data2(i,5) *25);
    end
    hold on;
end
plot (n (:1), n (:2),'xk’, ...
    'MarkerSize',10);
```

1.2 Question 1 Drawing related algorithmic procedures

```
clc
clear
```

```
close all
data1 = xlsread("data1.xlsx",1,'A2:E437');
data2 = xlsread("data1.xlsx",2,'A2:E604');
data3 = xlsread("red_camp.xlsx",1,'A2:F269');
data4 = xlsread("blue_camp.xlsx",1,'A2:F169');
A = zeros(436,436);    % Whether sites are connected to each other
for i = 1:603
    A(data2(i,2),data2(i,3)) = 1;
    A(data2(i,3),data2(i,2)) = 1;
end
Coordinates=data1(:,2:3);

% gplot(A,Coordinates,'k-')
hold on;
for i = 1:268
    plot(data3(i,2),data3(i,3),'.r',...
        'MarkerSize',data3(i,5)*25);
end
hold on;
for i = 1:168
    plot(data4(i,2),data4(i,3),'.b',...
        'MarkerSize',data4(i,5)*25);
end
hold on;

x1 = [82.9668,24.96753333];
y1 = [83.462875,22.78926667];
y2 = [82.991,16.81186667];
y3 = [80.48645,19.9578];
y4 = [85.612425,18.50613333];
y5 = [75.58335,26.92633333];
y6 = [75.8134,22.58926667];
y7 = [82.977025,27.41896667];
y8 = [89.759325,18.77366667];
y9 = [91.623275,23.86796667];
y10 = [98.4932,19.1062];
drawarrow(x1,y1);
```

```
drawarrow(x1,y2);
drawarrow(x1,y3);
drawarrow(x1,y4);
drawarrow(x1,y5);
drawarrow(x1,y6);
drawarrow(x1,y7);
drawarrow(x1,y8);
drawarrow(x1,y9);
drawarrow(x1,y10);

x2 = [76.756725,9.615333333];
y1 = [85.399925,15.66363333];
y2 = [78.862925,7.757066667];
y3 = [81.184325,9.865066667];
y4 = [86.0796,6.219533333];
y5 = [75.11325,13.63716667];
y6 = [74.067625,6.3984];
y7 = [78.813975,3.1215];
y8 = [83.925025,4.111466667];
y9 = [89.2823,7.992133333];
y10 = [81.848125,14.85973333];
drawarrow(x2,y1);
drawarrow(x2,y2);
drawarrow(x2,y3);
drawarrow(x2,y4);
drawarrow(x2,y5);
drawarrow(x2,y6);
drawarrow(x2,y7);
drawarrow(x2,y8);
drawarrow(x2,y9);
drawarrow(x2,y10);
% for i = [43 197 164 190 49]
%       plot(data3(i,2),data3(i,3),'ok',...
%            'MarkerSize',150);
%       hold on;
% end
% for i = [112 90 11 106]
```

```
%        plot(data4(i,2),data4(i,3),'ok',...
%              'MarkerSize',120);   % Blue square self-propelled gun attack range
diagram
%        hold on;
% end



clc
clear
close all
data1 = xlsread("data1.xlsx",1,'A2:E437');
data2 = xlsread("data1.xlsx",2,'A2:E604');
a = zeros(603,9);
for i = 1:603
    a(i,1) = data2(i,2);
    a(i,2) = data1(data2(i,2),2);
    a(i,3) = data1(data2(i,2),3);
    a(i,4) = data2(i,3);
    a(i,5) = data1(data2(i,3),2);
    a(i,6) = data1(data2(i,3),3);
    a(i,7) = data2(i,4);
    a(i,8) = data1(data2(i,2),4);
    a(i,9) = data1(data2(i,3),4);
end
b = ones(436,436)*inf;
for i = 1:436
    b(i,i) = 0;
end

for i = 1:603
    b(data2(i,2),data2(i,3)) = data2(i,4);
    b(data2(i,3),data2(i,2)) = data2(i,4);
end

[d,r] = floyd(b);

for i = 1:436
```

```
        for j = 1:436
                if d(i,j) == Inf
                        d(i,j) = 0;
                end
        end
end
t = zeros(6,1);

for j = 1:436
        if data1(j,4) == 1
                t(1) = t(1)+d(152,j);
                t(2) = t(2)+d(184,j);
                t(3) = t(3)+d(325,j);
        elseif data1(j,4) == 0
                t(4) = t(4)+d(48,j);
                t(5) = t(5)+d(70,j);
                t(6) = t(6)+d(161,j);
        end
end

for i = 1:436
        if data1(i,4) == 0
                d(161,i) = 0;
        elseif data1(i,4) == 1
                d(184,i) = 0;
        end
end
h = zeros(436,2);
for i = 1:436
        h(i,1) = d(161,i);
        h(i,2) = d(184,i);
end

clc;
clear;
close all;
data = xlsread("blue_camp.xlsx",1,'B2:C169');
```

```
[n,p]=size(data);
K=8;D=zeros(K,2);
for k=2:K
[lable,c,sumd,d]=kmeans(data,k,'dist','sqeuclidean');
sse1 = sum(sumd.^2);
D(k,1) = k;
D(k,2) = sse1;
end
plot(D(2:end,1),D(2:end,2))
hold on;
plot(D(2:end,1),D(2:end,2),'or');
title('Clustering bias plot of different K values')
xlabel('Number of categories (K values)')
ylabel('Sum of squared errors within clusters')
```

1.3 Algorithm for unweighted undirected graphs between points

```
clc
clear
close all
data2 = xlsread("data1.xlsx",2,'A2:E604');
n=436;      % Set the adjacency matrix size
temp=1;   % Setting the starting point
b = zeros(436,436);
for i = 1:603
    b(data2(i,2),data2(i,3)) = data2(i,4);
    b(data2(i,3),data2(i,2)) = data2(i,4);
end
% Constructing Adjacency Matrix
s = data2(:,2);
t = data2(:,3);
w = data2(:,4);
G = graph(s,t,w);
plot(G)
```

2. Question 2 related code

2.1 Goal programming algorithm program

```
clc
clear
close all
data1 = xlsread("data1.xlsx",1,'A2:E437');
data2 = xlsread("distance.xlsx",1,'B2:E437');
syms k1 k2 k3;
r = 25650;
b = 37146;
p = zeros(436,1); % Troop deployment at all points
t = zeros(436,3); %1 -Cargo loading time, 2 -cargo transportation time, 3 -cargo unloading time
% k = [0.3 0.4 0.3];
%zeros(1,3); %1 -demand rate for medical supplies,2 -demand rate for military supplies,3 -demand rate for daily necessitiesx = [0.00004 0.00005 0.00003]; %zeros(1,3);
y = [0.00004 0.00005 0.00003]; %zeros(1,3);
H = data2(:,1)+data2(:,2); %zeros(436,1); % Cargo transportation distance
c = 50; % Speed of vehicle
n = 436; % Number of points
t1 = 0;
t2 = 0;
t3 = 0;

for i = 1:436
    if data1(i,4) == 1
        p(i) = r/data1(i,5);
    else
        p(i) = b/data1(i,5);
    end
end
a1 = 0;
a2 = 0;
a3 = 0;
```

```
for i = 1:436
        if data1(i,4) == 1
                a1 = a1 + x(1)*k1*p(i) + x(2)*k2*p(i) + x(3)*k3*p(i);
                a2 = a2 + H(i)/c;
                a3 = a3 + y(1)*k1*p(i) + y(2)*k2*p(i) + y(3)*k3*p(i);
        end
end

a = a1+a2+a3;
% for i = 1:436
%         if data1(i,4) == 1
%                 t1 = t1 + t(i,1);
%                 t2 = t2 + t(i,2);
%                 t3 = t3 + t(i,3);
%         end
% end

clc
clear
close all
data1 = xlsread("data1.xlsx",1,'A2:E437');
a = zeros(436,2);
for i = 1:436
        if data1(i,4) == 0
                a(i,1) = sqrt(abs((data1(i,2)-82.9668)^2 + (data1(i,3)-24.96753333)^2));
        else
                a(i,2) = sqrt(abs((data1(i,2)-76.756725)^2 + (data1(i,3)-
9.615333333)^2));
        end
end

clc
clear
close all
data1 = xlsread('length.xlsx',1,'A1:PT436');
data2 = xlsread("data1.xlsx",1,'A2:E437');
a = data1;
```

```
b = zeros(436,2);
for i = 1:436
    for j = 1:436
        if a(i,j) == 0
            a(i,j) = Inf;
        end
        if data2(i,4) == data2(j,4)
            a(i,j) = Inf;
        end
    end
end

for i = 1:436
    b(i,1) = min(a(i,:));
    if b(i,1) == Inf
        b(i,2) = 0;
    else
        b(i,2) = find(b(i,1) == a(i,:));
    end
end
```

3. Question 3 related code

3.1 The Red attacks the blue retreats related code

```
clc
clear
close all
data1 = xlsread("data1.xlsx",1,'A2:E437');
data2 = xlsread("data1.xlsx",2,'A2:E604');
data3 = xlsread("red_camp.xlsx",1,'A2:F269');
data4 = xlsread("blue_camp.xlsx",1,'A2:F169');
A = zeros(436,436);    % Whether sites are connected to each other
for i = 1:603
    A(data2(i,2),data2(i,3)) = 1;
    A(data2(i,3),data2(i,2)) = 1;
end
```

```
Coordinates=data1(:,2:3);

% gplot(A,Coordinates,'k-')
hold on;
for i = 1:268
    plot(data3(i,2),data3(i,3),'.r',...
        'MarkerSize',data3(i,5)*25);
end
hold on;
for i = 1:168
    plot(data4(i,2),data4(i,3),'.b',...
        'MarkerSize',data4(i,5)*25);
end
hold on;

y1 = [76.756725,9.615333333];   %161 command post
y2 = [79.506525,0.7677];   %37 Point of departure
y3 = [74.082625,9.188766667];   %140 Point of departure
y4 = [86.1134,2.665];   %378 Point of departure
x1 = [75.58335,26.92633333];
x2 = [75.0958,22.56076667];
x3 = [82.977025,27.41896667];
x4 = [79.296575,25.10543333];
x5 = [84.460625,18.07713333];
x6 = [83.130725,16.66253333];
x7 = [81.307325,16.6505];
x8 = [78.386,24.60896667];
x9 = [82.69935,22.37843333];
x10 = [82.735375,20.2525];
x11 = [91.623275,23.86796667];
x12 = [77.495625,22.53223333];
x13 = [98.4932,19.1062];
x14 = [89.759325,18.77366667];
x15 = [85.75485,18.54036667];
x16 = [82.18965,18.829];
drawarrow(x1,y1);
drawarrow(x2,y1);
```

```
drawarrow(x3,y1);
drawarrow(x4,y1);
drawarrow(x5,y2);
drawarrow(x6,y2);
drawarrow(x7,y2);
drawarrow(x8,y2);
drawarrow(x9,y3);
drawarrow(x10,y3);
drawarrow(x11,y3);
drawarrow(x12,y3);
drawarrow(x13,y4);
drawarrow(x14,y4);
drawarrow(x15,y4);
drawarrow(x16,y4);
text(77,9.615333333,'161Command point');
text(79.7,0.7677,'37Evacuation point');
text(74.5,9.188766667,'140Evacuation point');
text(86.5,2.665,'378Evacuation point');
```