Solving the problem of determining the optimal location of the logistics center, taking into account cost minimization

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Abstract. The problem of placing distribution centers for the delivery of goods as part of the optimization of product distribution is a strategic task that needs to be addressed. This article describes a model for determining the optimal location of a distribution center based on geographic coordinates. Based on the methodology of the model, it finds the most optimal location for a given demand. For a more accurate solution, the optimization algorithm does not include an abstract measurement system, but is designed to solve the problem of the location of the distribution center on a location map. An example is shown that the proposed model and algorithm are reliable and can effectively cope with solving problems of this kind. The model proposed in this article has not only a theoretical structure, but is also tested to solve practical problems of choosing the location of distribution centers.

1. Introduction

In recent years, on-time delivery of goods is possible only with the optimization of goods distribution. One of the important tasks facing transport companies is the uncertainty of consumer demand for goods, since timely delivery is an important condition for the efficient functioning of production in general and the economy in particular. Currently, up to 30% of cargo is lost in the supply chain until the consignee reaches it, which implies huge economic losses [1-5]. The strategically correct location of distribution centers helps to increase the safety of goods, reduce the distance of transportation between objects, keeping to the terms [6-9].

The location and size of distribution centers are of great importance for the design of the transport infrastructure of the city [10], and will affect the time, speed and cost of delivery. Large logistics companies build or lease space that they use to create distribution centers in a district / city / region analyzing market demand in order to optimize the distribution network location and reduce costs. The size and location of the distribution center may vary over a period of time, with changing consumer demand. The location of the distribution center is developed in accordance with the distribution plan for quick response to changes in demand [11-16]. Therefore, it is important to consider consumer demand when choosing distribution centers.

2. Theoretical basis

The transport network of the city often has a need for a distribution center that will satisfy customer requirements when moving goods. There are many studies on the location of cargo distribution centers with various models and optimization algorithms. The best known for solving this problem are: an optimization model using the genetic algorithm and the heuristic method of local search; hybrid...
method; a network design model that combines decision-making on the location of distribution centers with respect to orders, taking into account the heterogeneity of the quality of goods, to ensure comprehensive differentiation of flows.

Consider an iterative algorithm for determining the coordinates of the distribution center. The coordinates of the distribution center are found by formulas (1) and (2).

\[
x_j = \frac{\sum_{i=1}^{n} a_i Q_i}{\sum_{i=1}^{n} R_i(j-1)}(j-1) \\
y_j = \frac{\sum_{i=1}^{n} b_i Q_i}{\sum_{i=1}^{n} R_i(j-1)}(j-1)
\]

(1)

(2)

where \( j \) - iteration number; \( Q_i \) - the need of the i-th settlement for inventory items, thousand tons, determined by the formula:

\[
Q_i = q_i S_i
\]

(3)

where \( R_{i(j-1)} \) – approximate distance from the proposed distribution center to the i-th settlement, determined by the formula (4).

\[
R_{i(j-1)} = \sqrt{((a_i - x_{j-1})^2 + (b_i - y_{j-1})^2}
\]

(4)

where \( x_{j-1} \) and \( y_{j-1} \) – abscissa and ordinate of the proposed distribution center obtained in the (j-1) -th iteration.

Obviously, to start the iterative process, it is necessary to know the approximate coordinates of the proposed distribution center \((x_0, y_0)\), which were determined by formulas (5) and (6).

\[
x_0 = \frac{\sum a_i Q_i}{\sum Q_i}
\]

(5)

\[
y_0 = \frac{\sum b_i Q_i}{\sum Q_i}
\]

(6)

Distances from settlements to the distribution center with coordinates obtained at the initial stage \( R_{i(0)} \) were determined by the formula (7).

\[
R_{i(0)} = \sqrt{((a_i - x_0)^2 + (b_i - y_0)^2}
\]

(7)

The iterativemethod flowchart is shown in Figure 1.

3. Practical use

The testing of this algorithm was carried out in the Irkutsk region with an area of 2646 sq km and a population of 1015 thousand people, including the city of Irkutsk, the Angarsk city district and the Shelekhovsky municipal region. Irkutsk region has the following structural zones: historical urban core; the central zone, which includes, in addition to the urban core, the nearest intensively built-up territory to it; external zone with continuous but less intensive development. The region is a major transport and logistics hub located on the shortest international transit corridors connecting Europe with the countries of the Asia-Pacific region.
The city of Irkutsk with settlements included in the Irkutsk region forms a multicomponent system with intensive production, transport and cultural ties. Since the Irkutsk region is the center of Siberia for cargo transportation, increasing cargo turnover every year, it is on it that effective mechanisms for the development of the transport sector will be tested and worked out, one of which is the optimization of the distribution center location with the determination of geographical coordinates.

When developing such an application, it is possible to enter the coordinates of settlements directly on the map. This functionality is implemented using the GMap.NET library, a free control for the open source .NET platform. It provides convenient methods for working with maps, providing a choice of dozens of maps available for free (including Google Maps, Yandex Maps and others). The figure shows the selection of objects on the Google Maps map, the determination is carried out interactively and is marked with red markers, after calculating the coordinates of the distribution center, a green marker corresponding to its location is also applied to the map. When you hover over which its coordinates are displayed.

![Block diagram of determining the optimal location of the logistics center by the iterative method.](image-url)
4. Conclusion

According to the results of a survey of the movement of freight transport at the entrances to the cities of the Irkutsk Region, it has now been established that about 600 vehicles with an authorized maximum mass of over 3.5 tons leave different directions every hour. Of these, about 300 cars per hour, with a carrying capacity of more than 8 tons. Most of the intraregional cargo turnover falls on intra-district and intra-city transportation, especially direction Irkutsk-Angarsk-Cheremkhovo-Zima. Transport infrastructure in the Irkutsk region, as in most cities of Russia, ensures stability of the growing capitalization of the territory. To reduce the transport load, optimization of goods distribution was proposed taking into account the location of the logistics center, which is quite an urgent task within our region.

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