Simulation and Modeling of Emergency Dispatch Based on Multimode Transportation

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Abstract: Emergency dispatch is a dispatch problem, which is based on multimode transportation. To aim at the complexity of infection factors and difficulty of dispatch decision-making of emergency dispatch, this text adopts the way of combining analysis of mathematical modeling and OOA, by dint of IDEFO function model analysis, established object oriented, modularized and arrangement dynamic visualization simulation model of single assignment of emergency dispatch. By optimization of emergency dispatch, achieving scientific management and reasonable arrange of emergency supplies; by combination of multiple transportation, abbreviating emergency dispatch time, achieving maximal benefit, providing assistant decision-making of emergency supplies dispatch.

Keywords: emergency supplies dispatch, simulation, mode, object oriented

1 Introduction

Emergency supplies dispatch is by the situation of facing emergencies (such as war conflicts, natural disasters, terrorist attacks, etc.) we need emergency mobilization and transporting supplies for required. Emergency dispatch is so complex that many factors affect the dispatch decisions are difficult to be quantified; strategy information is also uncertain and incomplete.

For resource dispatch, Linet had proposed to minimize the transport time of relief resource transportation model to solve the dynamic changes over time of goods transport. Barbarosoglu had put forward a network flow model, which is a two-stage multi-mode of transport, and many types of cargo, to simulate the supplies transport plan to minimize the transportation costs. Research on Path Optimization based on multimode transportation has important theoretical and practical significance for supply chain logistics services to achieve the target of timely, accurate, safe, fast, and to achieve optimal service. Ziliaskopoulos and Wardell had researched on the problem of the condition of shortest path under multimode transportation network, and had given out an optimum algorithm for path problem under time restriction. Angelica Lozano had studied multimode transportation issues under the shortest possible path, and solved the problem through the sequential algorithm. These models are basically focused on the choice of routes, in line optimization and scheduling optimization of the combination of means of transport are not yet perfect. More research on this paper to provide emergency supply dispatch problem in theory.

This paper focuses on the problems of emergency dispatch under multimode transportation. By considering the path strategy as a constraint of making allocation decisions, the problem is divided into two problems of paths optimization problem and resource allocation problem. Through the analysis of emergency supplies dispatch, the paper has built a object-oriented dynamic visualization simulation model, which is object oriented, modular and hierarchical, of a single emergency dispatch task. By optimizing emergency supplies dispatch problems, shortening the activation time, maximizing the benefits, so as to provide decision support to emergency supplies dispatch.

2 Analysis of Emergency Supplies Dispatch Based on Multimode Transportation

2.1 Correlative concepts
In order to facilitate the discussion, here specifically the following concepts:
(1) Emergency supplies: According to different purposes, supplies can be divided into protective equipment, life rescue, life support, rescue transport, temporary accommodation, pollution clean-up, dynamic materials, engineering equipment, equipment tools, lighting, radio communication, transportation, construction materials, etc. 13 categories. The reserve materials can be different because of geographical disparities.

(2) Multimode transportation: According to the definition made by the European Conference of Ministers of Transport (1997), multimode transportation has broad and narrow sense. Multimode transportation narrowly defined as follows: use a continuous mode of transport but not in the mode of transport for cargo conversion of cargo handled their own separate mobile (using the same loading unit or tool). Multimode transportation broadly described as follows: Use at least two different modes of transport for cargo movement. Studies of the paper based on broad definition multimode transportation.

(3) Emergency supplies dispatch based on multimode transportation: is process of according to requirements of emergency material support mission, based on the principle of support, scientifically selecting various modes of transport for optimization of transport path, reasonable allocation of goods and materials, and finally make out the plans of emergency dispatch of support supplies. The process and material support in order to meet the objectives of timely, flexibility and effectiveness of the requirements of emergency, organizing and implementing emergency support.

(4) Resources point: units, that there are emergency supplies reserve, which have the ability to provide emergency resources. It includes the central warehouse and local warehouses.

(5) Requirement point: The object of protection of emergency supplies, which need supplies support.

(6) Transportation mode: This article refers rail, sea, air, highway, secondary roads, tertiary roads, fourth roads as modes of transport.

2.2 Principle of emergency supplies support dispatch
First, if the local storage could meet the requirement, emergency supplies will be provided by local repertory storehouse.
Second, if the local storage couldn’t meet the requirement, command center can harmonize other local storehouses to meet the requirement.
Third, regardless of any way of accommodating, it must meet the time restrict requirement.

2.3 Hypothesis of emergency supplies dispatch
Dispatch issues on emergency supplies agreed to follow the following two main principles: First, the scientific principle that the agreement can not affect the nature of the problem; Second, the feasibility of the principle that the agreement content must comply with the basic reality. The paper has given the following conventions:
1. Time and cost of all levels of warehouse loading and unloading of materials is set to known values.
2. Considering of the influence by dangerous of road and node under emergency conditions.
3. Location and demand of requirement point is known.
4. Considering using of rail and road modes of transport goods, but between two nodes can only choose one mode of transport.
5. Equipment for loading, unloading and delivery can meet the requirement of emergency dispatch.
6. One resource point can provide materials for a requirement point by other resources point (as is the transfer case), meanwhile, this resource point can provide materials for other requirement points.
7. If the demand for each requirement point can be satisfied, they should be satisfied in one dispatch issue; speed of each transportation mode is known as constant.

2.4 Description of dispatch problem and cost model
Emergency supplies dispatch problem can be described as: Within a given area, the demand of \( h \) requirement points \( D_n (n = 1,2,\ldots, h) \) should be satisfied by \( S \) resource points \( P_m (m = 1,2,\ldots, s) \), the
quantities of requirement points as \( b_n \ ( n = 1,2,...,h ) \), the storage of resource points as \( a_m \ ( m = 1,2,...,s ) \). Transport form \( P_m \) to \( D_n \) should pass by \( k \) nodes, and there are \( g \) modes of transportation between any neighboring nodes for selection. Path section and the nodes have their own dangerous factor, and the time, costs, risk of transportation in the two neighboring nodes are different from different transport mode, when in a node needs to change from one mode of transport to another mode of transport, it will produce a certain loading and unloading time and loading and unloading costs, but also in the transport process can not exceed the total time limit \( T \) of the dispatch. Select of the optimal path between \( m \) resource point and \( n \) requirement point to make the cost of each good minimum by considering of all the affect factors. Select of the optimal path of other resource points to requirement points Ibid.

After getting the optimal path and transport cost of each good among all resource points to requirement points, the problem can be changed to transportation problems. In the paper, we define transport cost of each good as broad sense cost of normal transport problem, which aim at minimum of the whole cost of each path. We can get the supply quantities of each resource point providing for each requirement point by solving the problem, and make out the dispatch plan for the special area. For the whole process, in accordance with the process solution, until all requirements are met, get the ultimate dispatch decision.

According to the above problem description, cost of support transportation of materials in a single mission formed by the following parts:

1. Loading cost (L): loading cost for the \( m \) resource point;
2. Transportation cost (T): all the cost of transport from \( m \) resource point to \( n \) requirement point;
3. Transfer cost (C): all the cost of transfer cost from \( m \) resource point to \( n \) requirement point;
4. Unloading cost (D): unloading cost for the \( n \) requirement point.

So the entirety cost of single task can be described as:

\[
G_m = L_m + T_m + C_m + D_{mn}
\]

Of which: both of time limits and dangerous factors are constraints for the transport process.

We can get the cost of the whole dispatch from single task cost. The overall objective of emergency supplies dispatch is to minimum the whole dispatch cost (H) under the time limit and with or without dangerous conditions.

\[
\min H = \sum_{m=1,2,...} G_m
\]

### 3 Analysis of Simulation Modeling of Emergency Supplies Dispatch

According to the above analysis of emergency supplies dispatch problem, the stochastic parameters of emergency supplies dispatch have increased the difficulty of the problem. Aiming at the complexity and variability of the problem, and the characteristics of complex discrete event dynamic system, the paper uses object-oriented methods for modeling and analyzing emergency supplies dispatch, and has build IDEFO function analysis model.

#### 3.1 Object oriented analysis of the problem of emergency material dispatch

In order to establish modular, object oriented simulation model of emergency supplies dispatch problem, the paper divides its object into three categories.

1. **Entity objects**
   - Including static entity objects (resource point: reserve materials, loading and unloading capacity, location and other attributes; requirement point: requirements, location, security and time attributes),
   - dynamic entity objects (vehicle: car, truck, loading and other properties; road: type, length, transport
costs and other property; transfer point: loading, unloading capacity; material: type, quantity, transportation costs, handling costs and other property).

(2) Information objects

Information objects are used for searching and coordinating emergency supplies dispatch information timely, describing every parameter and change state of the whole dispatch process in detail. They are the important basic of carrying out the simulation model. Include:

• Requirement information (Attributes: requirement points, requirement quantities, the latest arrival time, route)
• Vehicle information (Attributes: type, load, number)
• Location information (Attributes: resource points, requirement points, transfer points, and road)
• Time information (Attributes: the latest delivery time)
• Requirement (Attributes: material type, quantity)
• Vehicle route (Attributes: type of road, depart time, route)
• Distribution information (Attributes: resource points, material types, quantities, requirement points)

(3) Control objects

Simulation procedures are controlled by control objects, which include: distribution control, route control, roads select control, depart time control, speed control, and loading and unloading control.

3.2 Analysis of IDEFO function model

IDEFO is a structured modeling and analysis method, IDEFO can both describe the process and data flow of emergency supplies dispatch, and can also describe the emergency supplies dispatch problem entirely, that is useful for establishing structured and modular simulation model.

With IDEFO, using the principle of top-down decomposition, first determine the overall function model diagram of the distribution process, shown in figure 1, the top-level functional blocks input parameters: requirement points (including demand), resource points and time limit information; the output information is: support decision, vehicle plan, route, simulation results analysis, that are controlled by road trigger, vehicle trigger, parameter maker, path algorithm.

According to the actual distribution process, based on the main line of vehicles, the paper has protracted the bottom lay function model graph. There are five steps of the single support issue: loading, depart, transfer (unload and load), arrive, and unload. After finish supporting for a requirement point, vehicle turn back to resource point or transfer point. According to the requirements, analyzing the supportability of resource points, making out support decision, and then send support command to resource points.

3.3 Target of simulation

The target of emergency supplies dispatch simulation is by simulating the process of emergency supplies dispatch process, analyzing affecters of dispatch process, forecasting the station that will be happened, estimating the dispatch decision, and finally give out optimal parameters configuration. All of these are from analysis of key factors, including: support decision analysis, time limit analysis, vehicle path analysis, loading and unloading cost analysis and transportation cost analysis.
4 Simulation Model of Emergency Supplies Dispatch

This chapter, the paper has built an object-oriented dynamic visualization simulation model, which is object oriented, modular and hierarchical, of a single emergency dispatch task, based on simulation software platform. Simulation model is driven by processes and event, according to basic restriction conditions input by users, analyzing the optimal transport path, simulating dispatch decision, arrangement of vehicles for deployment, simulating transport process, including the simulation of the loading, goods delivering, vehicles transportation, transit and delivery process, the dynamic changes for requirement, different speed for different types of roads.

4.1 Logic flow of simulation model
Simulation of the distribution process should first accord to the network of multimode transportation and the optimal path model, determine the optimal path between each resource point and each requirement point by using the Dijkstra algorithm, and then combine with cost analysis to generate decision of emergency supplies dispatch. Logic flow of the simulation model is shown in figure 3.

Figure 2: Bottom diagram a single transportation IDEFO
For the randomly generated demand and support capabilities required to carry out its limited supply and demand, that support capability must meet the demand; for the formation of a time limit is required to limit, that the optimal path mode, can meet the time constraints. In the simulation of the distribution process, when the simulation time at a certain scheduled time, road generation module and vehicle dispatching time module must be triggered. When the path generation module receiving the trigger command, it will immediately generate driving directions according to the path; after the vehicle dispatching time module receiving the trigger command, the vehicle set off from a resource point, and in accordance with the scheduled routes. In the course of the vehicle, the speed is controlled by the speed control module. Road speed control module control the speed and set parameters by analyzing the nature of the road. When the vehicle arrived at the designated transfer point, the loading and unloading control module controls the transfer process; when the vehicle reached the requirement point, the unloading control module will control the discharge process. After the simulation process, simulation results analysis module will analyze the simulation results.

4.2 Structure of simulation model
The overall structure of the simulation model based on software platform is divided into four parts: user interface, visual dispatch, information flow layer, simulation data analysis layer, as shown in figure 4. User interface is used for entering simulation parameters; information flow layer collects and generates simulation information, deal with the gathered information, and then send to other simulation layers, including: information of time, place, requirement, path, etc. Visualization dispatch layer show the place of resource points, requirement points, path, and the process of vehicle. Simulation data analysis layer analyze the key factors of simulation result.
5 Conclusion

Emergency supplies dispatch decision, based on the multimode transportation, is the problem of materials distribution and path decision-making. Along with the rapid development of modern logistics technologies, it has significant practical value that research on emergency supplies dispatch. The paper has put forward simulation methods and model of the single task of emergency supplies dispatch. Assumed in the \( \theta \) level of support area, the cost of from resource point \( (m) \) to requirement point \( (n) \) is \( C_{mn}^{\theta} \), then the whole cost of dispatch is:

\[
C_{w} = \sum_{\theta} \sum_{m} \sum_{n} \theta \sum_{\omega}
\]

By regulating parameters that affect the single issue of dispatch through simulation analysis, we can restructure the whole strategy of emergency supplies dispatch, forming optimal dispatch strategy.

References