LOGISTICS APPLICATION ON DISTRIBUTED COMPOSITE OBJECT BASED ENVIRONMENT

JAMSHID NAKHCHIVANSKI
Computer Engineering Department
Istanbul Technical University

GURAY YILMAZ
Computer Engineering Department
Air Force Academy, Istanbul

NADIA ERDOGAN
Computer Engineering Department
Istanbul Technical University

ABSTRACT
This paper presents an application of logistics on dynamic, shared systems. The system is implemented on a platform which allows for distributed objects to be shared among nodes located at dispersed geographical locations. The paper first defines the roles of customer, manager/mediator and provider nodes, and next describes the interactions among them. A new extension of Vehicle Routing Problem (VRP) [1], that minimizes logistical cost is also introduced and discussed in detail. Distributed Composite Object (DCO) model [2] forms the basis of the execution environment of the application. The middleware which implements the DCO model provides the basic mechanisms of communication and solves data sharing issues.
KEYWORDS
Distributed systems, object-based middleware, cooperative computations, object replication, logistics applications.

1. INTRODUCTION

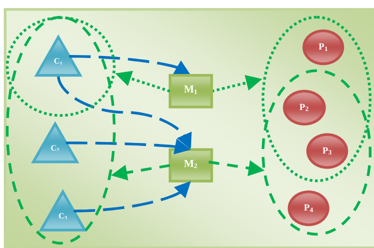
A simple logistic environment consists of several *customer* and *provider* companies. Customers are served various types of goods by set of vehicles in different providers [3]. In such an environment, both customer and provider sides not only undertake the required operations for buying and selling, but also partly undertake management operations. This aspect increases complexity of information processing and decreases scalability of the system when a customer or provider company works with many other companies [4]. The environment that has been developed to support logistic applications addresses these problems and presents better solutions for these types of problems. In this environment, management functions between customer and provider companies are given to the *mediator* companies.

2. GENERAL APPEARANCE OF LOGISTIC ENVIRONMENT

Customer, provider and mediator companies altogether constitute a logistic environment. Provider companies possess a variety of goods for sale and vehicles for transporting them. Customer companies determine their requests, sent them to the mediator companies. These requests reach provider companies only after being analyzed and finalized by mediator companies with agreement. Mediator companies have bilateral agreement with different provider and customer companies. They manage and supervise all buying and selling operations among provider and customer companies. Paths exist among the companies and goods are carried to companies via these paths. Typically, the costs of different paths vary. A vehicle that transports goods starts from a provider company visits some customer companies over its route, fulfilling customers' requests and finally returns to the owner provider company. In Fig.1, general appearance of the logistic environment is depicted. Boxes with green arrows describe customer companies; boxes with red arrows describe provider companies together some vehicles and materials. Blue boxes are mediator companies. They manage some provider and customer companies described with lines.

Fig.1. General Appearance of Logistic Environment

In Fig.2**,** communication appearance of logistic environment is described. Here M_1, M_2 are the mediator companies; P_1, P_2, P_3 and P_4 are the provider companies; C_1, C_2, C_3 are the customer companies. The mediator company M_1 has an agreement with P_1, P_3, P_4 and C_1. The mediator company M_2 has an agreement with P_2, P_3, P_4 and C_1, C_2, C_3. The customer company, C_1, sends its requests to both M_1 and M_2 mediator companies. In accordance with their evaluation and calculation, the companies, M_1 and M_2, send their results to company C_1.



M_i – mediator; P_i – provider; C_i– customer

Fig.2. Communication appearance of logistic environment

2.1. Execution Flow for Logistic Environment

Here, interaction steps between the companies in the logistic environment are shown. This structure seems like a protocol, and has some features [5]. It constitutes general working structure of the system - evaluation of requests of customer companies in mediator companies, calculating optimal solutions, getting information about sending goods to the customer companies over the mediator companies, which is fulfilled by provider companies.

In Fig. 3, working structure of logistic environment is described among several customer and provider companies and one mediator company.

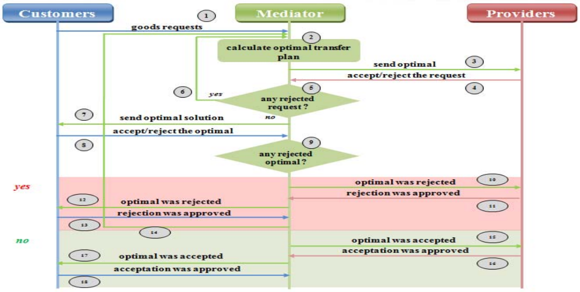


Fig. 3. Execution flow for logistic environment

3. MATHEMATICAL METHODS FOR CALCULATING OPTIMAL TRANSFER PLAN

From this point of work, we use the following words interchangeably: goods and material, provider company and depot, customer company and demand point.

Features of logistic environment describe that, different providers can sell the same type of material, and prices per unit of them may be different in various providers. And also features of vehicles carrying the same type of material can be different, such as capacity of vehicle, cost per distance of vehicle [6]. Thus, the total cost of demand point will depend not only on length of the route, but also will depend on material cost (selling price), material amount and vehicle cost (cost per unit distance).

Calculating an optimal transfer plan with these parameters emerges new problem to be solved. This problem is new type of Multi-Depot Vehicle Routing Problem (MDVRP) [7] .

Let the name of our problem be Enhanced Multi-Depot Vehicle Routing Problem (EMDVRP) which is a Multi-Depot Vehicle Routing Problem with Split Delivery and Variable Distribution of Vehicles for Transporting Heterogeneous Materials (MDVRPSDVDVTHM).

Below is the description of the EMDVRP.

1. There are M potential depots (denoted as set D) and each depot, i(i ϵ D), has v_{i_k} vehicles and m_{i_l} material types.

2. The capacity ($vcap_p$), cost per unit distance (vc_p) and load type (vl_p) of vehicles v_p,(p ϵ{1,2,...,i_k}) of depot, i(i ϵ D), can be different. Each vehicle v_p has route, R_p, serving several customers, starting out from its corresponding depot, i, and returning to the same depot. The same vehicle may serve several times, after returning to its depot, at a time when there are not enough vehicles.

3. Selling prices (material cost) (mc_q) of the same material types m_q, (q ϵ{1,2,...,i_l}) are different in various depots.

4. All N customers (denoted as set C) must be served and each of them can be served more than one vehicle.

5. Demand of each customer, j(j ϵ C), may contain several material demands, Dem_j ={dem_{j1}, dem_{j2},…, dem_{jr}}. Each material demand, dem_s(s=j_1,j_2,…,j_r), can be satisfied by the vehicles of different depots.

6. It is possible that, the demand of served customer exceeds the capacity of serving vehicle, in this condition the demand of customer may be fulfilled by more than one vehicle, which is known as split delivery [8].

The EMDVRP problem is formulated as the following programming model:

$$\text{Total Cost} = \sum_{a\in C}\sum_{b=1}^{p_a} Z(dem_{ab}) \quad (1)$$

$$\text{Minimize All } Z(dem_{ab}) = \sum_{i\in C\cup D}\sum_{j\in C\cup D} dis_{ij} \sum_{k=D}\sum_{c=1}^{v_k}\sum_{l=1}^{r_{kc}}\left(x_{ijkcl}\cdot vc_{kc} + amt_{kcl}\cdot mc_k\right), \quad a\in C, b=\{1,2,\dots,p_a\} \quad (2)$$

$$\sum_{k=1}^{u}\sum_{l=1}^{r_k} P_{abkl} = dem_{ab} \quad (3)$$

dem_{ab} – demand for material type b of customer a

p_a – demand count of the customer *a* (how many different material types are demanded)

dis_{ij} – distance between the points

v_k – vehicle count of depot k for serving demand dem_{ab}

r_{kc} – route count of vehicle c of depot k

x_{ijkcl} – equals 1, if the vehicle *c* of depot *k* travel to demand point *j* directly after demand point *i* in its *l*'th route, otherwise equals 0.

vc_{kc}-cost of vehicle *c* of depot k

amt_{kcl}- amount of paid part of demand dem_{ab} , taken away from depot k by vehicle *c* of depot k, in its *l*'th route

mc_k – cost(selling price) of material type dem_{ab} of depot k

P_{abkl} - delivery amount of material type *b* at demand point *a* by vehicle *k* in its *l*'th route

Equation (1) describes the total cost function of all demands, which equals sum of cost function of all different type material demand of all demand points (2).

Constraint (3) ensures that demand point *a,* which needed dem_{ab} amount of material type *b* equals the sum of amount of material type *b* carried by vehicle *k* in its *l*'th route which only visited to the demand point.

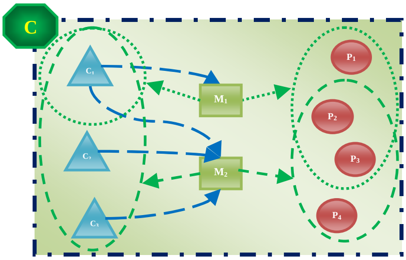
4. LOGISTICS APPLICATION ON DCOBE

An actual logistics application includes several features such as dynamic control on a distributed environment, should be robust and scalable, and is expected to provide the optimum solutions to generate rapid responses to queries and to minimize costs. DCOBE system presents some important properties, which allow the development of applications that possess these features [2].

4.1. Use of DCOBE on logistics application

As we know from the structure of DCOBE system [2], there is DC on the selected node and all other nodes have DS's which are controlled by DC. DS's provide communication of different user applications, running on the nodes, data transmission, and data update and so on over DC. DC can be placed on any node where user application runs. Here we illustrate how to use DCOBE system on logistic environment, which we explained in section 2.

Communication structure of logistics application is shown in Fig.4. In all the other nodes, user applications run and communicate with C over the network. Dash-dotted lined shape in the Fig. show that all nodes inside it are under the control of node C. Every node except C describes one company and suitable user application works at each of them.



C – central node M_i – mediator; P_i – provider; C_i– customer companies

Fig. 4. Communication structure of logistics application

5. CONCLUSION

This paper describes the implementation of a logistics application on DCOBE framework, focusing on design phases. We argue that the composite structure distributed objects made available by DCOBE framework improves application performance as only a relevant part of an object is transmitted between nodes, reducing the amount of data flow between nodes. Furthermore, the consistency management capabilities of the system enable facilitates data sharing. Currently, work is being carried on evaluating system performance and scalability under various workloads.

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