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B2C E-commerce Vehicle Delivery Model and Simulation

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Abstract: B2C e-commerce develops quickly in China, mainly for the express logistics. China's national economy has always been growing steady and fast in the recently decades, it provides a good external environment for the development of the express logistics. B2C e-commerce logistics distribution system should be a part of the city logistic, some characteristics of B2C e-commerce logistics services cause logistics distribution to be difficult, such as large quantity, small batch, high timeliness, dispersion and uncertainties and so on. Based on the work about optimization and scheduling of e-commerce vehicles, this study intends to solve the optimization and scheduling of non-fully-loaded delivery vehicles under the constraints of traffic conditions and time window. It should improve the efficiency of the B2C e-commerce delivery.

Key words: Business to custom (B2C), electronic commerce (e-commerce), logistics, vehicle, model, simulation

INTRODUCTION

The recent explosion in the development and capabilities of the internet is changing the requirements for effective supply chain management. Electronic commerce and associated B2C transaction capabilities have changed the way in which the supply chain operates. The Internet has enabled information exchange on an unprecedented scale, often at a pace too fast for normal consumption. However, increased access to real-time information has not guaranteed that companies are able to do something with this data or, more importantly, to do the right thing with it. In addition, although companies may now share a number of real-time data streams, including supplier or customer warehouse levels, key customer ordering patterns and relative location of important supply chain assets, little evidence exists to suggest that something is being done with this information (Roorda *et al*., 2010). The sheer volume of available data is too massive for any one person or group of people to decipher. Furthermore, no real data analysis tools currently exist that are capable of comprehending real-time information and making informed decisions based on it (Liu and Lyons, 2011). The advent of computerization and the Internet has revolutionized most warehouse operations. Internet technology allows warehouse managers to receive orders more expeditiously and allows them to track the inventory connected with those orders (Golob and Regan, 2011). There are some drawbacks, however. Because the Internet has provided a lower cost way of placing an order, warehouses are experiencing more frequent, smaller quantity orders. This makes the task of consolidating orders to economic shipment quantities more challenging. It also forces companies to confront the trade-off between quick-response (more frequent shipments) and inventory carrying cost.

Increased shipments typically increase transportation costs while decreasing inventory holding costs-thus the characteristics of the product being moved or stored, such as its value, size and typical demand pattern (seasonal or regular) determine if the savings in inventory holding costs pays for the cost increase in transportation. Real-time information of the product flow becomes the tiebreaker for both sides of the business equation in terms of trading off transportation and inventory costs (Van Duin *et al*., 2007). Companies are not suitably equipped to make informed, effective decisions based on the data collected separately by warehouse management systems-which contain data such as supplier/customer warehouse inventory levels and key customer ordering patterns-and by transportation management systems-within which information pertaining to the location of important supply chain assets such as products or vehicles is typically stored (Haughton and Isotupa, 2012). For example, a company today may have full knowledge of an order cancellation prior to the orders scheduled delivery time but is very often unable to react to the situation in real-time through rerouting or other corrective action. Thus, even though company's visibility into supply chain inventories is constantly improving, this improved visibility has not translated into companies making better decisions (Mason *et al*., 2003).

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Electronic commerce is a good service mode along with information technology and networking in the 20th century, represents the future trade and consumption mode (Rutner *et al*., 2003). Online shopping is becoming the normal pattern of consumption in China According to the 2010 China's online shopping data, it shows that the amount of market transactions in 2010 reached 523.1 billion yuan, representing an increase of 109.2% over 2009. In 2009, the online shopping market transactions occupied the total annual social consumer goods retail sales the proportion of 2%, up to 3.3% in 2010. In fact, e-commerce logistics is development with e-business technology and social development demands, it is a important part to achieve is the real economic value in electronic commerce. The technology of E-commerce logistics is to offer the invisible techniques in electronic commerce activities for goods to removal and storage. The function is to transport goods from plants to consumers through electronic commerce. The logistics technology is related to logistics functions and implementation in electronic commerce activities (Ramanathan, 2010).

A context-specific work that comes closest to the transportation and logistics field is Sabria and Daganzo, in which the context is cargo-handling at marine ports (Liu and Lyons, 2011). As was the case with these latter two studies, our work aims to broaden the empirical scope of scheduling systems research on non-healthcare contexts (Kim *et al*., 2008). We accomplish this by modeling the heretofore unexamined setting of queues at border (Customs) checkpoints for trucks carrying freight between Canada and the USA (Secomandi, 2000). We note that while several other researchers have also considered truck scheduling (Reijula *et al*., 2010). Boysen *et al*. and Miao *et al*. on scheduling trucks involved in-their findings cannot be drawn on for insights here (Tavasszy *et al*., 1998)]. That is because of substantive differences between their work and ours. As an example, the context of interest here is largely probabilistic (e.g., service times) and is a multi-phase queuing system whereas the work by Boysen is in a deterministic single-phase setting (Tong and Liu, 2012).

In this study, we intend to solve the work about optimization and scheduling of non-fully-loaded delivery vehicles under the constraints of traffic conditions and time window based on B2C e-commerce logistics system.

REQUIREMENT OF A CURRENT LIMITER B2C E-COMMERCE LOGISTICS DEVELOPMENT IN CHINA

The total Internet economy is large and rapidly growing. The total world Internet economy is forecast to reach $ US 2.3 trillion by 2003. More than half of all revenue is generated by the Internet industry serving itself. According to the official website of the China's National Post Office website in 2011, the amount of business of courier service enterprises which can cover the whole country completed a total of 3.67 billion, an increase of 57.0%; its output was a total of 75.8 billion yuan, an increase of 31.9%;it increased 346.2% compared with the amount of business of courier service enterprises in 2006 and business output increased 252.9%. 2006-2011 China express business outputs are in Fig. 1. According to relevant statistical analysis, China's GDP growth is close contract with the growth of the express industry. When China's GDP grows 1%, the express industry will grow at the rate of three times. It is expected that China's GDP will reach 55.8 trillion yuan in 2015 at the average annual growth of around 7%. It also means that China's express industry in the next few years will grow at an average annual growth of 21%.

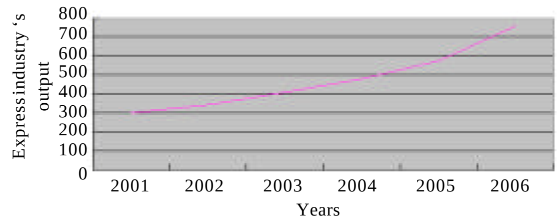

Fig. 1: 2006-2011 China express business outputs

B2C E-COMMERCE LOGISTICS DISTRIBUTION SYSTEM

E-commerce logistics system is based on the characteristics of the B2C e-commerce sales logistics and the level of logistics services that the e-commerce businesses to achieve which can link the various elements like the storage, transportation, information processing of logistics distribution activities to achieve distribution objectives, functions and roles in the formation of an organism. B2C e-commerce logistics distribution system should be a part of the city logistics. Because B2C e-commerce logistics services are individual, some characteristics of B2C e-commerce logistics services cause logistics distribution to be difficult, such as large quantity, small batch, high timeliness, dispersion and uncertainties and so on. B2C e-commerce logistics distribution is divided into city distribution and non-city distribution, regardless of city distribution and non-city distribution, the end of logistics distribution system consists of customer, distribution center, delivery vehicle, city distribution road environment and information of logistics distribution.

B2C E-COMMMERCE LOGISTICS DISTRIBUTION MODEL

For the e-commerce logistics distribution system, because distribution customers of e-commerce are scattered and the demand of each customer is not large that its size and weight are basically less than volume and load of a distribution vehicle, in addition, each customer's high demand of accuracy and speed of delivery time and the service area of B2C e-commerce logistics distribution system in the inner city, traffic conditions have tremendous impact on its distribution operations. Especially in some large cities where the traffic conditions are not optimistic, the traffic conditions more become an important factor in vehicle scheduling work.

The description of the network space after introduction of node variables is shown:

$$N = \{L, P, D\}$$

where, L represents the set of directed arcs constituting the network, or the set of road links; P represents the set of network nodes, or the set of road intersections and distribution nodes; P contains network nodes of the number of m; D represents the direction.In addition, S represents the set of distribution nodes and contains distribution nodes of the number of n, so $S \subset P$:

$$L = \{(V_{ij}, Q_{ij}, d_{ij}) | i, j = 1.2...m\}$$

where, V_{ij} represents the capacity of the arc between node i and node j (Traffic capacity or ability); Q_{ij} represents the arc flow between node i and node j (Traffic flow); d_{ij} represents road length between node i and node j:

$$P = \{(x_i, y_i, d_i) | i, j = 1.2...m\}\}$$

where, x_i is the abscissa of node i in the electronic map (or is represented of node longitude); y_i is the ordinate of node i in the electronic map(or is represented of node in the electronic map(or is represented of node longitude); d_i represents the delay time of distribution vehicles of node i (including delay time of intersection and residence time of distribution nodes).

$$D = \{d_{st} | t = 1, 2...n\}$$

$$d_{st} = \begin{cases} (+1,+1) & x_s \le x_t, y_s \le y_t \\ (+1,-1) & x_s \le x_t, y_s > y_t \\ (-1,+1) & x_s > x_t, y_s \le y_t \\ (-1,-1) & x_s > x_t, y_s > y_t \end{cases}$$

Model assumption

Objective function: It consists of three parts. The first part says the time constraints of travel expenses are not considered; the second part says the sum of waiting costs when the distribution of vehicles arrive early; the third part says delay costs when delivery vehicles are later than the customer's time window.

c_{if} means the transportation cost from i to j; t_{ij} means spending time from i to j; Si means the time when delivery vehicle arrives at the customer i. S_i claims to fall in (Ai, B_i) as much as possible. C_2 means vehicle waiting unit time and M means the punishment value to postpone the implementation of the unit time.

Objective function is:

$$Z = \sum_i \sum_j \sum_k c_{ij} x_{ijk} + c_2 \sum_j \max(A_j - S_j, 0) + M \sum_j \max(s_j - B_j, 0)$$

Constraints of the model:

- **Constraint of road conditions:** The constraint of road traffic conditions includes traffic conditions (roads or sections of restrictions of freight vehicle traffic, time constraints of one-way street restrictions freight vehicle traffic and freight vehicle models limit) constraints and traffic of freight vehicles (road traffic capacity and saturation limit) constraints

Mainly considering the impact of traffic constraints on the matrix, C_{ij} matrix is taken as a vehicle directly from i (customers or distribution centers) tol(customers or distribution centers) of operating costs matrix which it's proportional to t_{ij} which means shortest path running time of the vehicles. It mainly includes the link travel time forecasting and intersection delay time prediction.

- **Time constraint:** Time window means it may not provide services in the specified period of time but it must compensate for customer losses if not in this time to provide services. Transport constraints and the characteristics of the hard time window are added to the standard distribution stowage model

Centralized distribution and stowage model assumption: Centralized distribution and stowage in an integrated general description of the problem is that there is a distribution center to serve l customers. The assumption is that each client's weight g_i is less than the rated load q, seeking to the number of vehicles k and vehicle routes to meet the minimum distribution costs (including vehicle costs and time costs).

The mathematical model is as follows:

$$\text{MinZ} = \sum_i \sum_j \sum_k \text{CijXijk}$$

$$\begin{cases} \sum_i g_i Y_{ki} \le q & \forall K \\ \sum_k Y_{ki} = 1 & i = 1, 2.., L \\ \sum_i X_{ijk} = Y_{kj} & j = 0, 1, 2....L \\ \sum_i X_{ijk} = Y_{ki} & i = 0, 1, 2.....L, \forall k \\ \sum_{i,jes} X_{ijk} \le L - 1 & \\ X_{ijk} = 0 \text{ or } 1 & i, j = 0, 1, ...L, \forall k \\ Y_{ki} = 0 \text{ or } 1 & i, j = 0, 1 .....L \end{cases}$$

where, i means the number of distribution centers and customers and distribution center number is 0 as well as the customer's number is from 1 to l;

When the client task is completed by the vehicle, y_{ki}=1, or is 0; when the vehicle from i to j, x_{ijk} =1, or is 0. c_{ij} means the transportation cost from i to j and it may be evaluated of distance, cost or time. t_{ij} is the most short-circuit running time from i to j.

Equation 1 means that the total weight of each vehicle loaded cargo can not exceed the vehicle load.

Equation 2 limit for each customer only by a car's service.

Equation 3 and 4 limit only a car can come in and go out from each client node.

Equation 5 constrains that distribution of vehicles in any one customer does not form a loop.

The simulation calculation

- **Algorithm design**
  Encoding: Firstly, an initial number N of vehicles is determined in accordance with the Equation 4-24 and an number N-1 of vehicles are understood as the N-1 virtual distribution centers. The encoding of these the number of N-1 virtual distribution centers and the actual distribution centers are all set to 0 and they have the same coordinates (or the same position) with the actual distribution centers. Each virtual distribution center of the access path all represents the vehicle back to the distribution center and the distribution vehicles complete the distribution tasks, so as to form a loop. Each loop represents the distribution path of each vehicle. Customer coding adopts natural number coding and 1 represents the number of l for customers
- **Determine the initial group:** The initial group is evolutionary group in the beginning and the determination of initial group is divided into two steps for this problem

Step 1: Including 0, 1, 2... l of the initial group is generated with the recent heuristic method. The distribution center 0 is as the starting point and the nearest point of the choice of other unvisited points is as a successor until all cities have been visited

Step 2: Virtual distribution center of the N-1 (encoded as 0) is inserted in each initial individual generated from the previous step and is inserted as the following principles: from the first gene in the chromosome, if:

$$\sum_{j-1}^{t-1} g_i \le q \quad \sum_{j-1}^{t} g_i > q$$

(j represents customer point of j-bit gene of the chromosome and g_i represents the weight of the goods of the client), t-bit to the last gene are all backward one bit and the t-bi tis empty, so 0 is inserted. Then the insertion point is identified after starting from the t-bit according to the above principle and 0 is inserted until all virtual distribution centers all inserted

- **To generate simulated data**
  Road network defaults: in this example 100 network nodes of the grid mesh road network are taken as a distribution service area. The transport network is made of the main roads and secondary roads, including three horizontal (South, South, South 10) and three vertical main roads (West 1, West 6 and West 10); seven horizontal and seven vertical secondary roads. Node location of each intersection to cross the vertical axis is labeled and each road is equipped with long (6 km) in length as a unit. The speed limit of main roads is set to 60 km h^{-1} and the speed limit of secondary roads is set to 40 km h^{-1}. Three horizontal saturations of the main roads from south to north are set to 0.8, 0.6, 0.4 and three vertical saturations of the main roads from west to east are respectively set to 0.8, 0.6, 0.4 and the saturation of secondary roads is set to 0.5

The intersection signal cycle of main roads and main roads intersects is set to 120 sec. The two phase settings are that green signal ratio is set to 0.475 and the critical

Table 1: Caculation results

Vehicle serial number	Customer service	Walking path of the delivery vehicles (list only the line when turning the node)
1	1, 2, 21, 24, 28, 12	(1, 1), (3, 1) (1, 1) (2, 6), (3, 6), (3, 9)
2	29, 23, 7, 9, 6, 8, 11	(6, 8), (6.9), (9, 4) (4, 1), (1, 2), (6, 2), (7, 2)
3	4, 30, 22, 3	(1, 1), (6, 1), (6, 4), (5.4)
4	26, 13, 27, 14, 20	(10, 5) (10, 1) (1, 7), (8, 3), (8, 4)
5	15, 17, 18, 16	(2, 1), (2, 10), (2, 8), (1, 8)
6	25, 5, 10, 19	(1, 1) (7, 1) (1, 1) (1, 5)

traffic flow ratio is set to 1:1.The intersection signal cycle of main roads and secondary roads is set to 60 sec. The two phase settings are that the green signal ratio is set to 0.45 and the critical traffic flow ratio is set to 2:1. The intersection signal cycle of secondary roads and secondary roads is set to 45 sec. The two phase settings are that the green signal ratio is set to 0.43 and the key traffic flow ratio is set to 1:1. customer basic information is in Table 1.

Randomly generated the following the 30 customers within a given road network, including the nature of the customers' time window, location and weight.

The calculation resultsWithin the use of programmed calculation, the algorithm reached the requirements of the best chromosome 10 times through 521 iterations and obtained the following optimal solution (shown in Table 1 and the required number of the vehicles is 6.

CONCLUSION

China's B2C e-commerce logistics develops quickly, mainly for the express industry. In this study, we analyzed that logistics distribution system consists of customer, distribution center, delivery vehicle, city distribution road environment and information of logistics distribution, then solved out the work about optimization and scheduling of non-fully-loaded delivery vehicles under the constraints of traffic conditions and time window through B2C e-commerce vehicle delivery model and simulation.

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