DISTRIBUTION SYSTEM META-MODELS
IN AN ELECTRONIC COMMERCE ENVIRONMENT

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Hung-Tse Ko
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Chapter 1

Introduction

Background

Businesses became interested in the internet almost as soon as it appeared. Consumers can purchase their desired merchandise in user-friendly, consumer oriented homepages that are presented by companies seeking to expend their marketplace. Today, commercial activity on the internet has increased to the point where hundreds of companies are adding web pages daily. In 1995, more than $83 million was spent worldwide on website development. By 1998, these total web expenditures increased to $2.6 billion (Ng, Pan, and Wilson 1998). In 2000, electronic commerce (EC) on the internet is predicted in US dollars 100 billions of dollars per year and growing (Hamilton, 1999). The entire business environment has changed in the past decade. Many global conglomerates began to think that EC could be their new tool to access both next (short term) and future (long term) markets (Liang and Haung, 1998). The popularity of EC has grown over the last few years as more people begin to realize the benefits of using various computer and communication technologies to ease business procedures and increase efficiency. EC provides an alternative channel to conduct business that is facilitated by over 25 enabling technologies including electronic data interchange, electronic mail, and on-line interactive services (Ng, et al., 1998).

Amazon.com is a good example of this growth phenomenon. Amazon.com began its service on the internet in 1995 and its market capitalization was 25.3 million. In the fourth quarter of 1999, it reported net sales of 676 million, a 167% increase over net sales
of $253 million for the same quarter the year before (Bacheldor, B., 2000). The company that began in July 1995 as a pure on-line bookseller has become out of the most well known global cyber shops in less than a decade. Now, they not only sell books, they also sell electronics, toys, and computer parts under their “zShops”.

Because of the recent success of companies like Amazon.com, many computer and hardware manufacturers or sellers (Gateway, Dell, Compaq, Onsale.com. and Buy.com) began developing their own on-line web sites. Basically, three different types of business model are considered in this market: consumer-to-consumer (or C-to-C such as “ebay.com” or “Yahoo auction” on-line auction models as well as various on-line classified listing services), business-to-consumer (or B-to-C such as cdnow.com or buy.com, JCPenny, Circuit City, Wal Mart, and etc.) and business-to-business (or B-to-B such as Ariba, Commerce one, and Nike and its OEM partners). For now, consumer-to-consumer and business-to-consumer models are the most common types of electronic marketplaces (Gamble, 1999). However, in terms of gross dollars some people believe that the business-to-business marketplace will be the most dominant business model in the future (Gary, R. 1999).

Although EC has brought a great impact to industries and businesses, it also brings its share of problems with its benefits. For instance, customer databases can be very unpredictable and unreliable. Also, the need to ship every order quickly has seen a dramatic increase. Third, the order tracking routines may not adequately match the reality because the situation has changed during the transportation of goods.
The objective of this thesis is to develop and build an analytical meta-model for such systems and to develop a set of policies to calculate the cost of order tracking routines for both consumers and sellers (distributors). This thesis has one basic assumption: The optimal solution to a system is elusive at best, but one can find a "good" solution given a guiding set of policies.

1.1 Motivation for this research

The objective of this research is to develop a common and useful mathematical meta-model to compute the cost of transportation for both consumers and businesses. As mentioned above, this is a distribution system, which is characterized by a dynamic distribution and volatile system. The information on customer demand and inventory changes quickly.

In the past, most researchers in this field have focused on static distribution models. These all had one basic assumption: all of the operation variables (such as costs, demands, and so on) are all assumed to be variables without considering time as a factor. Therefore, if ones uses these models to calculate, say, the transportation cost, one might find that the data does not match the real situation.

On the other hand, research about dynamic systems has been developed over the last 30 years (Larsen, Morecroft, and Thomsen, 1999). In real life, customer's demand is uncertain and it is not easy to find a function to model this. Instead of trying to find a mathematic function directly, they used the indirect methods to model the variables in these studies.
In this research, we will try to study the characteristics of both static and dynamic systems. After developing those basic models, the next step of this research will outline some of the methods used to solve this problem. Then we will try to combine these two basic models into a new meta-model, which can be used for calculating the transportation cost within the context of EC.

The motivation of developing and solving the model is trying to offer the users (sellers and consumers) a reliable tool to help them to operate or manage their own business. From the seller’s point of view, they can use this model as a tool for analyzing their warehouse location problems, truck routing problems, and the inventory control for the warehouses’ operations. From the consumer’s point of view, this model could be used for determining a ranking of suppliers.

1.2 Scope of research

This research presents a set of formulas for modeling a dynamic distribution and an algorithm for calculating the cost of transportation. As shown in the Figure 1.1, the system under investigation has four basic components: consumers (customers), retailers (distributors), warehouses, and plants. In the structure shown, orders will be executed from customers to plants (upstream) and products are transported from plant to consumers (downstream).

![Figure 1.1 Basic structure of the production-distribution system](image-url)
Each of the four basic components, as shown as in Figure 1.2, has several relationships between it and other components. The model involves several different variables, which represent: cost, demand, distance, capacity and so on. As we examine this system, we note that it is very difficult to solve the problem mathematically (Larsen et al., 1999). This means that an optimal solution might be unavailable and/or unattainable. Therefore, it is necessary to develop an algorithm to help solve this problem and find an acceptable solution.

![Diagram of typical "e-tailer" distribution system](image)

**Figure 1.2** Diagram of typical "e-tailer" distribution system

### 1.3 **Significance of research**

Using the mathematical modeling, we can define a reliable model as a useful tool for transportation costing analysis. This type of model is typically represented by a set of linear formulas. In the past, decision makers may employed "Bender's decomposition" (Bender, 1962) as a method to find a good solution for a given transportation/transshipment problem (we can separate the objective function into two
parts and solve these two parts separately by using Bender’s decomposition). When the scale of the system under investigation is small, we can solve the associated mathematical program fairly easily. When the scale of system becomes large, this linear model may involve a huge amount of variables. This type of problem is more complex and an optimal solution becomes much more difficult to find.

In order to deal with this intractability, we can assume that the optimal solution is not easily found, but we can get an acceptable and reasonable solution by setting some rules or policies. In addition, the dynamic variables are not always easy to model. However, we can model these variables by setting an original value and updating them over time. As a result, we have an efficient way to analyze the costs involved with the associated problem.

1.4 Structure of the thesis

This thesis is structured as follows. Chapter two presents a review of the relevant literature for this study. This includes both literatures on static distribution and dynamic system modeling as well as finding acceptable solutions. Chapter three presents the approach to the problem. This includes the definition of the problem as well as the assumptions about the problem under investigation. Chapter four presents the modeling steps and methodologies. Chapter five presents a discussion of the modeling and optimization methodologies. Some extensions of this work are also presented.
Chapter 2

Literature Review

In the real-time product distribution systems that are prevalent in EC business models, several different and complex business relationships exist. These relationships have high impact roles within these types of systems. Basically, we can classify the components of such systems into two different areas of study: (1) characteristics and behaviors of EC and (2) dynamic product distribution system modeling and solution finding techniques. Several researchers have made efforts to help define or classify these basic relationships. While doing so, they also developed several analytical models for the analysis of real-time production distribution systems. This chapter will review and discuss literature that has been published on these two topics.

2.1 Characteristics and behaviors of EC

De and Mathew (1999) described the management system of EC as a conceptual framework. They classified the whole framework into four management categories: management of investment, management of quality, management of change, and management of technology organization. They noted that these four management subjects should each integrate their own management of information technology. Based on the aspects of information technology the management of investment focuses on (1) cost saving and management control, and (2) an emphasis on product quality, customer service, flexibility, and speed. The management of change focuses on the reactions of the constantly changing demand and environment, which will force the companies to make their own internal change in order to compete in an ever-increasing global market place.
The management of quality stresses the quality of processing and finished products. The management of technology organization defines the relationships between the main roles of an EC system and the integration of the four roles. They also tried to involve the dynamic technology of the world-wide-web as an important factor, integral to any management system for EC.

Forehlich, Hoover, Lew, and Sorenson (1999) described their experiences with developing a framework of building engineered-products business applications, so that these applications can be delivered over the internet. In this paper, they tried to provide the users with, an application framework architecture that contains the scope and information that they needed in the design of their framework. They began their discussion about EC and framework applications with some general concepts. Then, they focused on the demand problem from the web-site business models. This led to a general discussion of the requirements for an EC system. Their own experiences were also used as illustrations for the whole concept.

Aalst and Wil (1999) compared EC with traditional workflow management. They also stressed the process aspect of EC by relating it to workflow management. In this paper, they reviewed new and existing architectures that enabled inter-organizational workflow. The presentation focused on two approaches to partition an inter-organizational workflow over multiple business partners. Both approaches are evaluated. One of the key ideas in this paper is the possibility to verify the correctness of the inter-organizational workflow. The dynamics of the marketplace, with its rapid changing business processes and relationships, underlines the need for such verification tools.
Liang and Huang (1998) developed a model based on transaction cost theory. They assumed that customers would always choose a channel (market place) that has lower transactional costs. In other words, whether a customer would buy a product electronically is determined by the transaction cost of the channel. The transaction cost of a product on the web is determined by both uncertainty and asset specificity. An empirical study involving eighty-six internet users was conducted to test the model. Five products with different characteristics (books, shoes, toothpaste, microwave oven, and flowers) were used in the study. The results indicate that first, different products do have different customer acceptance on the electronic market. Second, this customer acceptance is determined, at least partially by the transaction cost, which is in turn determined by the uncertainty and asset specificity. Third, experienced shoppers are concerned more about the uncertainty in electronic shopping, whereas inexperienced shoppers are concerned with both.

Boll, Grauner, Haaf, and Klas (1999) presented a database of business and marketing system (DBMS)-based EC architecture and its prototypical implementation for business-to-business commerce according to a $n$-suppliers: $m$-customers scenario. Business transactions within the electronic market are realized by a set of modular market services. Multiple physically distributed markets can be interconnected transparently to the users and form one "virtually" central market place. The modeling and management of all market data in a DBMS gives the system a solid basis for reliable, consistent, and secure trading on the market. The generic and modular system architecture can be applied to arbitrary application domains. The system is scalable and can cope with an increasing
number of single markets, participants, and market data due to the possibility to replicate and distribute services and data and herewith to distribute data, system, and network load.

Wurman, Walsh, and Wellman (1998) considered a general family of auction mechanisms that admit multiple buyers and sellers, and determined market-clearing prices. They analyzed the economic incentives facing participants in such auctions, demonstrating that, under some conditions, it is possible to induce truthful revelation of values by buyers or sellers, but not both, and for single- but not multi-unit bids. They also performed a computational analysis of the auctioneer’s task, exhibiting efficient algorithms for processing bids and calculating allocations.

2.2 Dynamic product-distribution system modeling

An on-line product distribution system contains two sub systems: product distribution systems and dynamic system. We will discuss some of the literature about product distribution models in section 2.2.1 and the literature about dynamic models in section 2.2.2.

2.2.1 Product Distribution Models

Geoffrion and Graves (1974) developed a set of linear formulas and successfully applied them to a real distribution problem for a major food firm with 17 commodity classes, 14 plants, 45 possible distribution center sites, and 121 customer sites. In their model, they tried to aggregate a complex system into a simple one by assuming the following operating conditions. First, several different commodities can be produced in several different plants with known capacities. Second, for each pre-defined customer zone (set of pre-specified areas), the demand for each commodity is known. Third, the
demand of each customer zone is shipped via a regional distribution center (DC) and each customer zone is assigned to a single DC. In this research, they used a set of quadruply subscripted variables to indicate the four basic roles in this system: commodities, plants, distribution centers, and customer zones. The goal of their model was trying to find a minimum transportation cost under the condition of known commodity demand as well as known capacities of the plants and throughput of the DC's. In this research, the total annual cost of a product-distribution system was separated into two parts: one is transportation cost for products and the other one is the annual operation cost for distribution centers. The second part of this paper tried to develop an algorithm to solve this set of linear problems by using "Bender's decomposition", which can be used to build the constraints for the associated mathematical program.

Bartakkeet, Bloomquist, Korah and Popino (1971) employed separated transportation variables for plant-to-DC and DC-to-consumer shipments. That is, they used two sets of triply subscripted variables to represent the variables of their model. One disadvantage of this kind of modeling methodology is the lack of flexibility for some applications, especially in losing some links of these two sets of variables.

Daskin (1985) introduced an overview of problems in logistics. In this paper, the author discusses the background and concepts of logistics system and tries to give some key points for the future research on this topic by discussing the current research in the following five categories: conceptual models of logistics; vehicle-routing models; facility-location models; integrated logistics models, and; models of shipper-carrier integrations. For each category, he summarized some of the results of previous studies in
Chen, Egbelu, and Wu (1994) developed some production planning models for a central factory with multiple satellite factories. The production planning problem of minimizing total cost, which consists of transportation cost, processing cost, raw material handling cost, and finished product inventory holding cost in the whole network of a central factory with multiple satellite factories. In this research, they formulated two sets of non-linear mathematical programs. They employed this method because of the two different raw material purchase plans used in their model. In the first model, the material ordering policy at any given factory is based on the aggregation of the raw material demands over all items to be manufactured in the factory during a given production period. In the second model, lot consolidation for ordering is not done, which means the amount of items in each lot will be different. In this model, they assumed that the raw materials for the items produced in different factories were ordered separately. These two different models combine the raw material supply factory selection problem, order size determination, order processing sequence, and material handling system to become a lower costing production plan. The main objective of this modeling research is to define a production plan, a raw material purchase policy between factories, and a selection of the factory site (producing or purchasing factory) to hold items in inventory in order to minimize total factory network cost.

Sarmiento and Nagi (1999) reviewed recent work on integrated analysis of production distribution systems, and identified some important areas where further research is needed. By integrated analysis, they understood analysis performed on models
that integrate decisions of different production and distribution functions for a simultaneous optimization. They reviewed work that explicitly considers the transportation system in the analysis, since they were interested in the following questions: First, how have logistics aspects been included in the integrated analysis? Second, what competitive advantages, if any, have been obtained from the integration of the distribution function to other production functions within a company and among different companies? In their review, they also started the following should be performed at the strategic level: (1) if it concerns the design of the distribution system, or at the tactical level, i.e., (2) if it concerns optimization problems for which the characteristics of the distribution system are provided.

2.2.2 Dynamic Models

Drezner and Wesolowsky (1998) proposed a location-allocation model that incorporated continuously distributed demands by making the cost charged to users by a facility, which is a function of the total users patronizing the facility. The users (consumers) select the facilities that they will use based on the charges of the facilities and the transportation cost. The customers are assumed to always choose the less expensive facility. In this paper, they tried to analyze the $p$-median problem. The $p$-median problem involves the location of $p$ facilities to minimize the total cost for customers. Each customer patronized the closest facility and its cost is proportional to the distance to the facility (transportation cost). Then, they assumed that when more customers patronized a facility, it became less attractive because the extended waiting time added to the driving time. Another related approach is assumed that demand is a
decreasing function of the cost of transportation i.e., if a facility is located farther away, demand decreases. They also assumed that customer patronized the facility that provides them the lowest total cost. Based on the basic structure and assumption the mentioned above, they develop a set of algorithms to help solve this problem.

Holmberg, Ronnqvist, and Yuan (1999) proposed an algorithm for the capacitated facility location problem with single sourcing. They tried to develop a new solution approach for the capacitated facility location problem in which each customer is served by a single facility. They developed a methodology to get a minimized cost for a given distribution system, which contains a set of potential location for facilities and a set of customers. They also tried to solve these problems by using the same Lagrangian heuristics, which have been shown to produce high quality solutions and, at the same time, be quite robust. They also proposed a primal heuristic, which based on a repeated matching algorithm. This algorithm essentially solves a series of matching problems until certain convergence criteria are satisfied and it also is incorporated into the Lagrangian heuristic. Finally, a branch-and-bound method, based on the Lagrangian heuristic was also presented.

Qu, Bookbinder, and Iyogun (1999) built an integrated inventory and transportation system model with modified periodic policy for multiple products. An integrated inventory transportation system is also developed with a modified periodic-review inventory policy and a traveling-salesman component. This is a multi-item joint replenishment problem, in a stochastic setting, with simultaneous decisions made on inventory and transportation policies. They proposed a decomposition method to solve
the problem, minimizing the long-run total average costs (major- and minor-ordering, holding, backlogging, stopover, and travel). The decomposition algorithm works by using separate calculations for inventory and routing decisions, and then coordinating them appropriately. A lower bound is constructed and computational experience is reported.

Larsen, Morecroft, and Thomsen (1999) developed and formulated a mathematical model for a dynamic production-distribution system. In the paper, they illustrated the relationships and behaviors of a dynamic production-distribution system by using a beer selling and distribution model. In this paper, they tried to put their focus on the behaviors of dynamic systems, not the relationships and rules of a distribution. In order to present the continuous changing behaviors, they added the time as a part of factors of the transportation variables. Basically, they tried to separate the continuously time line into several time periods. In every time period, they estimated original values for the variables and updated these values with system’s feedbacks.
Chapter 3

Problem Definition

In this chapter, we will try to classify and define the characteristics, components and behaviors of an on-line product distribution system. Basically, this problem can be separated into three parts (see Figure 3.1). The first is the definition of physical relationships and behaviors of an on-line selling system and the other is the development of a mathematic model of the first part. In modeling this type of system, we can separate the model in three different components: the basic structure of product distribution system, the operating conditions and dynamic behavior of the real-time systems, and the problem of combination. In the second part, we will focus on two problems: the modeling of distribution systems and the modeling of dynamic systems.

![Figure 3.1 Structure of modeling](image)

An on-line product distribution and selling system is not just selling products, it is a dynamic system with continuously changing demands and uncertain "environmental"
conditions. In this thesis, we will separate the system into two sub-systems. The first is the product distribution model and the second is the associated dynamic customer demand model. Then, we can integrate these two sub models by adjusting the operation conditions and modeling the dynamic behaviors.

3.1 Basic Structure of the Model

Physically, an on-line product distribution and selling system is a product distribution with dynamic operation variables and constraints (Blumenfeld, Burns, Daganzo, Frick, and Hall, 1987). Before approaching the dynamic issues, we need to decide on which type of business model we will focus on. This step includes a study of the physical structure of distribution system. This should be done before we attempt the dynamic part of the modeling of the larger system.

As mentioned previously, there are three basic model types that we will consider in today’s EC market: consumer-to-consumer, business-to-consumer and business-to-business. Basically, a business-to-business EC model is a system contains \( n \) suppliers and \( m \) customers (Boll et al., 1999). We consider two types of customers: one is a personal user and the other is a business partner for the EC model. In this thesis, we will focus on the business users as the client side of EC system.

On the other hand, there are two types of sellers that we need to consider for the models here in. The first type is a company with its own manufacturing and the other of type is without their own manufacturing (such as Amazon.com or Cdnnow.com). Both of these two business types of EC sellers can be considered as the role of sellers. But from the modeling point of view, they will be considered different. When we want to model the
first type of sellers with manufacturing, we have to combine the production with the inventory-distribution and the vehicle routing problems (Benjamin, 1989; Blumenfeld, et al., 1987; Boll, et al., 1999). For the other business type of sellers, the whole system is an inventory-distribution-inventory model (Chandra and Fisher, 1994). In this thesis, we will focus on the inventory-distribution-inventory models.

An inventory-distribution-inventory model contains the following four basic components: retailers (suppliers), warehouses, distribution centers, and customers with several behaviors: ordering, transportation, restoring, and replenishing (Sterman, 1989). One of the simplest ways of modeling the system is that we link these four components together like a belt as in Figure 3.2. As shown below, the requested products are sent from the retailer’s warehouse to customer and this is the basic physical relationship between the four components. But the customers’ requests are dealt in a more complex way. For each request order, after received from the customer, it will be separated into several parts, which contain the requested information of customer zone.

For the operation of the warehouse and the distribution center, we also have operational constraints, such as the transportation capacity of distribution center, the inventory level of each warehouse and so on. We will use these regional demands, the operation conditions and the transportation limits to calculate the each warehouse’s outgoing amount of the requested items under the minimum transportation and operation cost. Therefore, the main approach of this section is that how to define and model these conditions and relationships and then calculate each warehouse’s request amounts and get the minimum cost.
3.2 Dynamic system models

In the real world, demand is uncertain, especially in an EC business, because we will face the unpredictable customer location and customer's demand (Ng, 1998). The uncertainty not only starts from the unknown demand for a certain product or service; it is also from the changing environment. In an on-line selling and distribution system, orders can be received at any time. Therefore, a reliable mathematical model may not be available for simulating and modeling the whole system at any given time. However, we have the product distribution system, which is based on fixed values of constraints.

In the first part of this chapter, we developed the main structure of the system. An on-line selling system is not only just a production-distribution or inventory-distribution-inventory system. It also has the other particular characteristic: real time data updating and other optimal characteristics (Larsen, et al 1999). In section 3.1, all of the variables and operation condition are assumed to be in a "steady" state. This means that all of the constraints are in fixed values, not changing continuously. In order to present the characteristics of the on-line systems under investigation, we have to consider this system as a real-time system. In a real-time system, data is updated continuously. The value of
the operation variables changes over time (Larsen, et al. 1999).

In addition to the data-updating problem (how often to update), the entire EC environment is an uncertain environment. Unlike what we was discussed in section 3.1, the customer's demand is assumed as unknown. This becomes the main problem when we need to model an EC business system (Cohen and Lee, 1988). Every time we do the calculation, the values of constraints are different, because the entire environmental and operational conditions have changed.

It is necessary for companies to have flexibility for their operations. On the other hand, they are not able to predict the customer's next behaviors according to history. This adds to the difficulty of the inventory control and shipping management (Cohen and Lee, 1988). When we want to model a system like this, in addition to this basic structure, we also need to specify the customer's demand and operational requirements rather than using these requirements as rules to formulate the models.

From dynamic system model studies, we will find that these models are based on the assumption of a periodic policy, because in real world, the variables of customers' demand and environment change continuously. If we want to model these in a direct way, we would not be able to find an accurate way to express these variables (Larsen, et al., 1999; Petrovic, et al., 1998 and Potamianos, et al., 1997). Although we cannot obtain the exact value of demand, we can estimate an expected demand in particular period. As time changes, we include an adjustment for the demand (Larsen, et al., 1999).

The other major idea that we can get from these models is that every sector's status will affect its upstream and downstream sectors' next period performance. It means the
adjustments that we make for the uncertain variable should be based on this relationship. In addition, the result of last period also affects the value of these adjustments, which are used for this period. Instead of defining the variables in a direct way, we can define a data updating time. Then, we will define the rules of how to make adjustments for these variables.

3.3 Combination modeling

As mentioned in the beginning of the chapter, we can separate this problem into two sub-problems. The first is the modeling of the distribution and the other is the dynamic behavior modeling. In the first part of modeling, we will model the basic structure of a product-distribution system. Then, we will try to model the dynamic behaviors of an online selling system under the operation assumptions. Finally, these two sub-models will be combined together into one aggregate meta-model. The key point behind combining these two sub-models together is the relationships between the static and the dynamic models. As mentioned section 3.1, the output of each warehouse's requested amount is based on the customer's demand, the operational conditions, and the capacity limits. In the dynamic model we will assume that these three components are changeable. If we can put these uncertain factors of customer's demand, operational conditions, and capacity limits into the static model, we may get a result that is based on the uncertain constraints.

3.4 Mathematical Modeling

In first three sections of this chapter, we explored the main components, physical rules and operational constraints of our system. However, this is not enough for us to solve this problem. We still have to translate these physical rules and operational
constraints into analytical expressions.

Before we start this problem, we have to decide which variables are independent variables and which are dependent ones. As mentioned above, we can find that the value of constraints that will affect the result of each warehouse's requested amounts of items. Therefore, in the first part of our model we will treat all the constraints as independent variables and the requested amount as the only dependent variable. In addition to this, the parameters of operations, such as the unit cost of transportation and annual cost of warehouse and distribution center's operation, will be the coefficients of the analytical model.

For the second part of our model, the dynamic modeling, we will need to define a data updating period time (at the planning period), which means a time that defines how often that data will be updated. In addition to this, the mathematical functions or equations, which include the uncertainty in demand and other constraints, are the other important subjects of our model. Then we will try to integrate this sub system and the static sub system that we developed in the parts.
Chapter 4
Methodology and Discussions

4.1 Assumptions

Here are the assumptions that are used for modeling warehouse operations, inventory control, product transportations and dynamic system. The mathematical function and constraints of this meta-model are based on these assumptions

- In this model, the orders are received randomly and continuously.
- We update data and information once an hour and the updating due to the replenishing and shipping are done in this time.
- In every business day, we ship the products twice a day (one is in the morning and the other is the afternoon) and this only is done during the order receiving period.
- When the actual inventory goes below the safety inventory level, the replenishment starts immediately and only stops if the actual inventory rises above the target level.
- After the distribution centers, the shipments could be sent to customer or to the regional warehouse. We will consider this part as a routing problem and we are not going to model this in our modeling.
- For the operation of distribution center, we set a minimum and maximum throughput capacity limit for every distribution center.
- In the model, we have several customer zones. Each customer’s demand zone is assigned to a distribution center.
• In this model, we will assume that the unit transportation cost of each item is a constant over time.

4.2 Basic Structure

The simplest version of the problem to be modeled is the following: there are several types of product stored in several warehouses, with a certain inventory level for each type, the requested items can be shipped from several possible warehouses via regional distribution centers, which each customer zone is assigned to a distribution center, then sent to customers. As we can see from the above, there are four basic components in model: products, warehouses, distribution centers, and customer zones. Since there are four basic components in this model, we will consider these four roles as the four basic vectors for the operation variables. This first step of modeling a system is choosing the description of variables. In the thesis, we will discuss two methods: separated variables and integrated variables. Then, we choose one of these two methods to represent the variables.

4.2.1 Separated Variables

One of the easiest ways to describe the variables is using separated transportation variables. We divide the system into two parts: plant-to-distribution center and distribution center-to-customer shipments. For each part of the problem, we would use a set of triply described variables to represent the transportation variables (Bartakke, et al., 1971 and Gary, P. 1967).

One of the advantages of the separated variables method is that it makes for a simple model (Potamianos, et al., 1997). The basic concept of the separated method is that it
separates the whole product distribution system into several sub-systems, which contains sources, destinations and the shipments (see Figure 4.1). Since each sub-system only contains two coordinates, it becomes easier. Therefore, we can model each sub-system by considering the conditions that are within the particular portion of system. After modeling each sub-system, the next step is the modeling of the common functions and constraints. Finally we can combine these functions and constraints of sub-system and global system into an integrated model.

![Separated variables models](image)

Figure 4.1 Separated variables models

The other advantage of this method is the flexibility (Potamianos, et al., 1997). Since we separate the whole system into several pieces, if we make some adjustments within one sub-system, it will not necessarily change the result of the other sub-systems. This adds a level of convenience for modeling a complex system and modifying a huge system.

However, this method also has some disadvantages. One of these disadvantages is the lack of flexibility for some applications because this type of model cannot show the origin of a product once it arrives at a distribution center. When we only check the
second sub-system, we can find the items in every customer zone come from which
distribution center, but we are not able to backtrack where they are coming from. This
will add to the difficulty of management when we want to remodel the whole system.

In addition to this inability to provide back track ability, there is the other major
disadvantage of the separated variables. For example, in some particular situation, we
allow the products can be sent directly from warehouse to customer zone without through
a distribution (Geoffrion and Graves, 1974). We will find it difficult to model this
specific situation if we use the separated variables method. Due to this disadvantage, we
will not be able to get correct results for the overall performance easily.

4.2.2 Integrated Variables

Because of the major disadvantages mentioned above, we should consider the other
variable description method. Instead of decomposing the system into several small parts,
we can express this system in a more integrated way (see Figure 4.2). In the previous
section, we described a model of the system by modeling every sub-system’s local
objective functions and constraints. Then, we combine all of the sub-systems as well as
the global objective function and constraints. Instead of decomposing the entire system
into several parts and modeling every part here, we keep the focus on the entire system.
Basically, every vector of variables indicates one component (in this system, they are
warehouses, distribution centers, customer zones and product types) of this system. Some
operation variables may not be associated with all of the components. Therefore, we can
just use the vectors that are associated with the system.
One advantage of this method is that we will not miss any global function and constraints (Geoffrion and Graves, 1974), because this integrated subscripted transportation variables makes it easy to accommodate direct warehouse-distribution-customer zone shipments. Even though some of the constraints are not applied to the entire system (such as the constraints linking warehouses, and distribution centers) we still use the associated vectors and formulate these functions and constraints. The other major advantage is that we can get a more accurate data about overall performance (Geoffrion and Graves, 1974).

Figure 4.2 Integrated method
When the system of interest becomes more complex, it is more difficult to model this type of system in this fashion. This is one of the major disadvantages of the integrated method. Another disadvantage is that it is less flexible for the overall system. Every time we make some small adjustments within the system, we will need to remodel the whole system again. This is not an easy task for modeling a complex system.

**4.2.3 Modeling**

In this thesis, we consider the system as a four components system (See Figure 4.3). As shown above we can decompose the whole system into two sub-parts: shipments from warehouse to distribution center and from distribution center to customers. In addition to this, we also showed that we could make shipments from a warehouse to customers directly. Therefore, we will try to utilize both the integrated method and use the idea of partial modeling from the separated method.
The nomenclature for the variables that we will use for the meta-models is shown below in Table 4.1.
Table 4.1 Notation of static model

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>i</strong></td>
<td>index for products</td>
</tr>
<tr>
<td><strong>j</strong></td>
<td>index for warehouses</td>
</tr>
<tr>
<td><strong>k</strong></td>
<td>index for distribution centers</td>
</tr>
<tr>
<td><strong>l</strong></td>
<td>index for customer zones</td>
</tr>
<tr>
<td><strong>c</strong>&lt;sub&gt;ijkl&lt;/sub&gt;</td>
<td>unit transportation cost for product <strong>i</strong> from warehouse <strong>j</strong> to distribution center <strong>k</strong> to customer zone <strong>l</strong></td>
</tr>
<tr>
<td><strong>x</strong>&lt;sub&gt;ijkl&lt;/sub&gt;</td>
<td>units of products <strong>i</strong> from warehouse <strong>j</strong> to DC <strong>k</strong> to customer zone <strong>l</strong></td>
</tr>
<tr>
<td><strong>S</strong>&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>supply capacity for product <strong>i</strong> in warehouse <strong>j</strong></td>
</tr>
<tr>
<td><strong>D</strong>&lt;sub&gt;il&lt;/sub&gt;</td>
<td>demand of product <strong>i</strong> and customer zone <strong>l</strong></td>
</tr>
<tr>
<td><strong>y</strong>&lt;sub&gt;kl&lt;/sub&gt;</td>
<td>a 0-1 variable that will be 1 if DC <strong>k</strong> serves customer zone <strong>l</strong>, and 0 otherwise</td>
</tr>
<tr>
<td><strong>f</strong>&lt;sub&gt;k&lt;/sub&gt;</td>
<td>fixed portion processing and operating costs for DC <strong>k</strong></td>
</tr>
<tr>
<td><strong>v</strong>&lt;sub&gt;k&lt;/sub&gt;</td>
<td>variable unit cost of throughput for a distribution center at site <strong>k</strong></td>
</tr>
<tr>
<td><strong>LV</strong>&lt;sub&gt;k&lt;/sub&gt;</td>
<td>minimum throughput capacity of DC <strong>k</strong></td>
</tr>
<tr>
<td><strong>UV</strong>&lt;sub&gt;k&lt;/sub&gt;</td>
<td>maximum throughput capacity of DC <strong>k</strong></td>
</tr>
</tbody>
</table>

### 4.2.3.1 System Cost

The simplest way to define the cost for product transportation is the amount of product times the unit cost of shipping that item. This is the idea of how we compute the cost of transportation here. Therefore, for an amount of product **i**, the cost of shipping from warehouse **j** through distribution center **k** to customer zone **l** is **c**<sub>ijkl</sub> × **x**<sub>ijkl</sub> and the total cost of shipping will be:

\[
\sum_{ijkl} c_{ijkl} \times x_{ijkl}
\]  

(1)

In addition to transportation cost, we also have the general operating and cost of throughput for distribution centers:

\[
\sum_{k} [f_{k} + v_{k} \times \sum_{il} D_{il} \times y_{kl}]
\]  

(2)
4.2.3.2 Shipment from warehouse to distribution center

In every warehouse, each type of products has its inventory level in this warehouse. This is how we define the supply capacity of product $i$, $S_{ij}$. Since a warehouse does not only supply one customer zone, the total amount of product $i$, $\sum x_{ijkl}$, from this warehouse cannot be larger than $S_{ij}$.

4.2.3.3 Shipment from distribution center to customer zone

In addition to the supply capacity of warehouse, we also have allowed throughput capacity for a distribution center’s operation. Since, in this model, we assume that each customer zones is only assigned to a distribution center, the throughput capacity of distribution center can be defined as the total amount of demand from customers zones, which are assigned to this distribution center. However in this model we also allow that in some particular situation, the products can be shipped direct from a warehouse to a customer zone. For this reason, we apply this variable, $y_{kl}$, which is a 0-1 variable that will be 1 if distribution center $k$ serves customer zone $l$, and 0 otherwise.

\[
\sum_j x_{ijkl} = D_{il} \times y_{kl} \tag{3}
\]

\[
\sum_k y_{kl} = 1 \tag{4}
\]

\[
LV_k \leq \sum_{il} D_{il} \times y_{kl} \leq UV_k \tag{5}
\]
Therefore the main structure of this model is:

\[
\text{Minimize } \sum_{i,j,k,l} c_{ijkl} x_{ijkl} + \sum_{k} [f_k + v_k \times \sum_{i,l} D_{il} \times y_{kl}]
\]

Subject to

\[
\sum_{i} x_{ijkl} \leq S_{ij} \text{ [Supply constraint]} \quad (7)
\]

\[
\sum_{j} x_{ijkl} = D_{il} \times y_{kl} \text{ [Distribution constraint]} \quad (8)
\]

\[
\sum_{k} y_{kl} = 1 \text{ [Distribution center assigning constraint]} \quad (9)
\]

\[
LV_k \leq \sum_{i,l} D_{il} \times y_{kl} \leq UV_k \text{ [Distribution center transportation constraint]} \quad (10)
\]

\[
\forall x \in I^* \quad (11)
\]

### 4.3 Dynamic Behavior

In real life, customer's demand is uncertain, and complete information about the state of the system is not always available to the decision maker (Larsen, et al., 1999). In a dynamic supply chain, we have four basic roles: supplier, warehouse, distribution center and customer (see Figure 4.5). In a supply chain, products will move from seller to customers and requests move from customers to the seller. Before an order is given from a customer to the seller, the seller doesn't know how many items are going to sell to where. By the way, when a customer facing a stock out situation, he/she may switch to the other sellers.
When we facing an unknown demand problem, the first problem that we will face is what kind of mathematical function that we can use to express customer demand. However it is not easy in real business world because every industry has its own characteristics and the marketing behavior is also unpredictable. On the other hand, we also have to face the changeable supplier capacity and transportation capacity. This is also difficult to find a function to model or simulate. Therefore modeling these functions directly is not suitable and we need to find another method.

As mentioned above, the dynamic system is a continuous environment and the variables change over time. It is difficult to model this in a direct way. In the research about the dynamic systems, we can find that these models are based on the assumption of periodic policy (Larsen et al., 1999; Perovic et al., 1998; Potamianos, et al., 1997). Although we cannot get the exact value of demand, we can estimate an expected demand in the following period based on the observation of previous periods. As the time changes,
we can have an adjustment for the demand (Larsen, et al., 1999). This is the main idea of how we define our unknown demand, supply capacity of supplier, and shipping capacity in the supply chain model.

The other major idea that we can get from these models is that every sector’s status will affect its upstream and downstream sectors’ next period performance. It means the adjustments that we make for the uncertain variable should be based on this relationship. In addition, the result of last period also affects the value of these adjustments, which are used for this period. As our model does not include the portion of suppliers, the dynamic supply chain models will give us an idea of how to estimate our demands.

4.4 Combination and algorithm

The first and second parts of the meta-model herein were developed in the last two sections. We will try to combine these two parts together in the following discussion. As mentioned above, we face an uncertain environment in this system. Because of the uncertainty of demand, supplier and transportation capacity, we have to store the products in our warehouse to prevent “stock out” situations. On the other hand, excess inventory also causes unnecessary inventory cost. A set of inventory control rules should be applied to all sectors (Sterman, 1989). In this model, we will assume that every type of products in every warehouse has a target inventory level and a safety inventory level. When the actual inventory level goes below the safety inventory level, we will begin to complement. When the actual inventory level exceeds the target inventory level, we will stop complement (Petrovic, et al., 1998; Sterman, 1989).
As mentioned before, this is a dynamic system and the value of variables of this model is changing continuously. Before formulating the complex dynamic behaviors, we have to know the relationships between these variables. From the discussion in section 4.2, we find that the value of $x_{ijkl}$ is depended on the amount of demand $D_{il}$ and constraint of inventory level $S_{ij}$ and the capacity of distribution center $\sum_{il} D_{il} \times y_{kl}$. If we can know the value of demand, we can get the outgoing amount of each warehouse. In the other hand, from the discussion of section 4.3, we can find that the value of demand is unpredictable, but we can have an expected value for this variable. As time changes, we
can get an adjustment from the real situation, and then we can get a more accurate value.

One of the major differences between modeling a static system and a dynamic system is that one does not consider variables, which are in the static system, that change as time changes. But in a dynamic system, the situation is different and this is main reason of the periodic policies. If we can find a way to link this two together, our problem can be solved. From above, we get the following results:

Rule 1: In this model, the value of $S_{ij}$ is considered as the value of actual inventory level of products $i$ in warehouse $j$. When an order is received, we can use the linear equations, which developed in the first part of modeling, to get the values of all $x_{ijkl}$. Then the new actual inventory level of products $i$ in warehouse $j$ will become $S_{ij} - \sum x_{ijkl}$ before we begin to compensate the inventory.

Rule 2: As designed for the system, we update data more often than we ship products. Every time, after we updating data, the actual total throughput of distribution centers will increases. Therefore, the upper capacity of throughput of the distribution centers will be also different. The new upper capacity of throughput will be $UV_k - \sum D_a \times y_{kl}$.

As mentioned before, in real life, demands from customers are unpredictable (Sterman, 1989) and a reliable model function may not be readily available. Since we only can know our demand after we receive the orders and calculate the amount of products that needed to be shipped. Therefore, we can get the follow idea of modeling this system. Instead of formulating these complex dynamic behaviors mathematically, we
may consider developing an algorithm for computer programming.

In this model, orders enter into this system continuously. Instead of computing the linear programs every time when we receive a new order, we can separate each order in several sub-lists, which can indicate the demands of every type of products in every customer zone, and then collect the data. Every time we update the data, we calculate the linear programs and get the new values of $x_{ijkl}$. Then we apply rule 1 and 2 to get the new values of $UV_k$ and $S_{ij}$. The data updating due to the inventory compensating and shipping will not be done during the regular updating time. We will update them right after the compensating or shipping finished and the compensating and shipping are done in the orders receiving period. This is basic scheme of how we are going to model and simulate this system.

Table 4.2 Notation of dynamic model

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$i$</td>
<td>index for products</td>
</tr>
<tr>
<td>$j$</td>
<td>index for warehouses</td>
</tr>
<tr>
<td>$k$</td>
<td>index for distribution centers</td>
</tr>
<tr>
<td>$l$</td>
<td>index for customer zones</td>
</tr>
<tr>
<td>$o$</td>
<td>index for orders</td>
</tr>
<tr>
<td>$c_{ijkl}$</td>
<td>unit transportation cost for product $i$ from warehouse $j$ to distribution center $k$ to customer zone $l$</td>
</tr>
<tr>
<td>$x_{ijkl}$</td>
<td>units of products $i$ from warehouse $j$ to distribution center $k$ to customer zone $l$</td>
</tr>
<tr>
<td>$S_{ij}$</td>
<td>supply capacity for product $i$ in warehouse $j$</td>
</tr>
<tr>
<td>$D_{il}$</td>
<td>demand of product $i$ and customer zone $l$</td>
</tr>
<tr>
<td>$y_{kl}$</td>
<td>a 0-1 variable that will be 1 if DC $k$ serves customer zone $l$, and 0 otherwise</td>
</tr>
<tr>
<td>$f_k$</td>
<td>fixed portion procession and operating costs for DC $k$</td>
</tr>
<tr>
<td>$v_k$</td>
<td>variable unit cost of throughput for a distribution center at site $k$</td>
</tr>
<tr>
<td>$LV_k$</td>
<td>minimum throughput capacity of DC $k$</td>
</tr>
<tr>
<td>$UV_k$</td>
<td>maximum throughput capacity of DC $k$</td>
</tr>
<tr>
<td>$g$</td>
<td>the number of order received in this period</td>
</tr>
<tr>
<td>$D_{lol}$</td>
<td>demand of product $i$ of order $o$ in customer zone $l$</td>
</tr>
</tbody>
</table>
Procedure: we separate the continuous time into several different time periods. In each time period, we collect and classify orders and calculate outputs. Then, we update the data in the end of each period.

- Collect orders and separate these orders in several sub-lists and retrieve the values for the demand of product $i$ of Order $o$ in customer zone $l$, $D_{iol}$.

  For $h = 1$ to $g$

  $D_{il} = D_{il} + D_{iol}$

  If $y_{kl} = 0$

  $y_{kl} = 1$

  End if

- Get the values of $S_y$, $c_{ijkl}$, $f_k$, $v_k$, $LV_k$ and $UV_k$. Then substitute these values into equations (1), (2), (3), (4) and (5)

$$
\text{Minimize}_{x_{ijkl} \geq 0, y_{ijkl} \geq 0} \sum_{ijkl} c_{ijkl} \times x_{ijkl} + \sum_k [f_k + v_k \times \sum_{il} D_{il} \times y_{kl}] \\
\text{Subject to}$$

$$\sum_i x_{ijkl} \leq S_y \quad \text{[Supply constraint]} \quad (13)$$

$$\sum_j x_{ijkl} = D_{il} \times y_{kl} \quad \text{[Distribution constraint]} \quad (14)$$

$$\sum_k y_{kl} = 1 \quad \text{[Distribution center assigning constraint]} \quad (15)$$

$$LV_k \leq \sum_{il} D_{il} \times y_{kl} \leq UV_k \quad \text{[Distribution center transportation constraint]} \quad (16)$$

$$\forall x \in I^* \quad (17)$$
• Compute the values of from $x_{ijkl}$ the linear equations

• New $S_{ij} = S_{ij} - \sum_{kl} x_{ijkl}$ and New $UV_k = UV_k - \sum_{il} D_{il} \times y_{kl}$.

• Update the values of $S_{ij}^*, c_{ijkl}^*, f_k, v_k, LV_k$ and $UV_k$.

Note:

Here are the operating conditions that are used for modeling warehouse operations, inventory control, product transportations and dynamic system. The mathematical function and constraints of this meta-model are operating under these conditions

1. The updating of the inventory levels and shipping will not be done during the regular updating time. We will update them right after the complementing or shipping finished and the compensating and shipping are done in the orders receiving period.

2. After finishing the shipping and updating for this, the $UV_k$ will become the maximum value as we designed.

3. After the complementing and updating of this are done, the $S_{ij}$ will be returned the target inventory level of product $i$ in warehouse $j$.

4. The assignment of one customer demand zone to a distribution center is fixed, i.e., we already assign each customer demand zone to a specific distribution center in the system planning phase.

5. If the total requested amount for a distribution center’s download stream customer demand zones exceed this DC’s maximal transportation throughput capacity limit, the shipment will be separated into several lots. For example: the
total requested amount is 10000 units, but the DC’s capacity is only 5000 units. We will separated this shipment into two lots: we ship the first 5000 units in the first day’s shipment, then we ship the rest in the next day.
Chapter 5

Conclusions

The development of EC opens a lot of opportunity in today's market place. The EC is not a brand new category of business or industry. It is a new integrated marketing channel for individual retailer and companies to sell their products. It is also a new tool for consumers to search and purchase merchandises. Because it changes the characteristics and relationships of sellers and consumers, the traditional modeling method would not be suitable for modeling a system like this.

On-line selling and distribution-inventory systems are complex in nature. This is due to the many components and relationships of such systems. It also involves several dynamic relationships and behaviors. On the other hand, a reliable mathematical function of the customer's demand may not be readily apparent when we want to model a dynamic system such as this. After reviewing some of the theories of EC, distribution-inventory systems and dynamic systems, we proposed a new modeling method. Instead of modeling this system in a mathematical way, we can separate this system into two levels. In this first level, we developed the linear equations for the behaviors and relationships of basic distribution-inventory system. In the second level, we developed a set of procedures to simulate the dynamic behaviors.

One major advantage of this modeling method is that we can translate this model into a computer program easily and this is useful for the management to have a readily accessible tool. The other major advantage is that every time when we compute the output of the linear equations we can substitute different values for the operation
variables and get different results. This means that in spite of the changing of environment, such as cost of transportation rising, the capacity of distribution center’s throughput changing, or even of the delay of upstream suppliers, we can easily make the changes, without developing new equations and functions.

However, there is still room for improvement. Because this model is developed based on the simplified assumptions of inventory complement and shipping routing, we still can make our efforts in these places and make this model more reliable.
Bibliography


Appendix A

The internet explosion has brought a lot of impacts to the business world. Because of the rapid development of on-line computing technology, many companies start to consider EC as a new and powerful market for their future. In the other side, more and more consumers are getting into the brand new market. However, it does not only change the face of business and industries. It also changes the relationship between consumers and retailers. With the help of web pages and web tools, consumers can get a clear image of a particular company. The web site also provides a more direct way for customers to contact with this company for product information or technical support. Many differences exist between the traditional business world and EC. If we want to employ the EC, we must first know the differences between the traditional businesses and EC businesses, then we can make the necessary adjustments in our business models.

One of the basic concepts behind EC that we must understand that the development of EC is not trying to build a new category of business or type of industry. It is a new marketing channel for the companies to have a more efficient and integrated way to operate their businesses and sell their products and a new tool for consumers to purchase merchandises [Kiang, Ragh, and Shang, 2000]. In the past, companies can have their advertisements on TV, on radio, in magazines and in newspapers. Customers use the telephone or the fax machine to contact these companies and place their orders. But in EC, customers can have more direct way for them to find their desire merchandise and to contact with sellers. As mentioned above, companies will face a lot of changes in the EC environment. These changes are not only from the characteristics of the product. They are
also from the specific characteristics of every industry.

A.1 Products characteristics

There is a broad range of products available on the internet. They range from consumable goods to durable goods. In the past, consumers and retailers may have had some regional relationships between them. Customers usually bought products and services from retailers, which are near them. They can have clear images and well formal opinions about the products that they are going to buy, before they buy them. In EC businesses, the boundaries of businesses on the web are not defined by geography or national boundaries. They are defined by the coverage of computer network [Ng, et al., 1998]. Because these geographical boundaries do not exist, customers are now coming from any place in the world. This increases the risk and difficulty for businesses. Not every the commodity can be sold on the internet. The types of products should be limited. For example, perishable products, such as fruits, fish and the other kind of food, will not be easy to sell these types on the internet, because typically most buyers would like to see if these products are fresh before they buy them. According to Rebello’s research, the best selling merchandises on the web sites are music CDs, books, airline tickets, computer and the other commodities that buyers do not need to sample them before they buy them [Ng, et al., 1998].

In traditional marketing, we usually classify the products by their tangibility, nature and needs, and buying behaviors [Liang and Haung, 1998]. This method may not be suitable in EC [Kiang, et al., 2000]. This method can be easily to be recognized in the traditional marketing. But in EC industry, it is not easy to accomplish this. For example,
customers may not be able to see the active products before they purchase them.

In Peterson’s research, he tried to use the other method to classify the products [Liang and Haung 1998]. Instead of classifying products by their tangibility, nature and needs, and buying behaviors, he classified the products into two categories: search goods and experience goods. The search goods are the products that can be evaluated by their external information, the experience goods are the goods that evaluated by the user’s personal experience. It is easier for companies to set up their web pages to sell the search good because consumers can reach the web pages from a search engine by key in the key words and find the list of products. They can decide if they are going to purchase or not by judging products’ external information, which are provided on the web page. For experience goods, because the customer’s buying behavior is unpredictable and it is also difficult to predict consumer’s actual demand, they are not considered suitable for the EC.

A.2 Characteristics of industries

Different types of industries have different characteristics. This affects their acceptability by customers on the internet. According to a recent survey, the Yahoo! Directory recorded 205,596 companies under the category of “Business and Economy” in June of 1997. Among these companies, 16.33% were listed as “computer related” and this is the largest sub-category under this category [Ng, et al., 1998]. The major reasons for this are: first, the services and products involved are closely linked to the internet applications and second, they are easily demonstrated and transported to the users, who are prospective customers by the computer companies and computer literate. Entertainment is another strong sector (14.1%) due to the inclusion of sports and the
rapid of growth in the presence of the music industry. The third place is the engineering and manufacturing (11.95%), mainly due to the fast growing automotive-rated industries.

From this survey, we can make the following tents. First, as mentioned previously EC is not a new category of industries. It is a new channel for companies to develop and expend their marketing. Second, most users also expect companies to provide information about their products on these web pages so that they can find these products’ information easily. Third, in the EC world, users are expecting the companies to provide them a faster service and respond times. The key idea here is that companies will be forced to integrate our service and production, because the users are not only expecting the information about the products, they also want the companies to provide their consumer service through the internet. Therefore, we are not just providing our products’ information to the users. We also have to think about how provide our service on the internet, before we get into this new marketing channel.
This research is aimed at presenting a meta-model that will be used as a basic structure of modeling an on-line selling distribution system. In an electronic commerce (EC) business system, demand, operating conditions and environment are random and unpredictable. An EC business system also involves several sub-systems, such as: information, manufacturing, communication, and management. In addition to this, the entire system is based on a static distribution system and operated in a dynamic environment. Therefore, a reliable mathematic model is not to be available.

Instead of modeling this system in a direct way, we can separate the modeling into two levels. Within the first level, we will define and model the static distribution system. At the second level, we will define and model the dynamic characteristics and behaviors. Then we can combine these two together as a meta-model for the decision makers. Decision makers can use this meta-model as a basic structure for systems such as this.