REDESIGNING URBAN DISTRIBUTION NETWORK FOR PARCEL E-COMMERCE DELIVERIES

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JULY 2013

REDESIGNING URBAN DISTRIBUTION NETWORK FOR PARCEL E-COMMERCE DELIVERIES

A THESIS SUBMITTED TO

THE GRADUATE SCHOOL OF SOCIAL SCIENCES

OF

IZMIR UNIVERSITY OF ECONOMICS

BY

YİĞİT ÇEVİK

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

IN

THE GRADUATE SCHOOL OF SOCIAL SCIENCES

JULY 2013

Approval of the Graduate School of Social Sciences

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ABSTRACT

REDESIGNING URBAN DISTRIBUTION NETWORK FOR PARCEL

E-COMMERCE DELIVERIES

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July 2013, 89 pages

Since last years, the rise of electronic commerce (e-commerce) has captured a lot of interest. E-commerce is quickly superseding traditional commerce. This change severely affected the third party logistics service provider (3PL) companies since e-commerce deliveries differ from traditional deliveries in two main aspects: the average shipment size and the frequency of deliveries. As a result 3PL companies are redesigning their distribution networks in order to simultaneously decrease the costs and increase the on time delivery performance. This study is based on an innovative distribution idea applicable especially to e-commerce deliveries. The aims of this study are (i) redesigning the urban distribution network for e-commerce deliveries, and (ii) analyzing the potential impacts of this idea with an application.

Keywords: e-commerce, vehicle routing, location selection

ÖZET

E-TİCARET KARGO TESLİMATLARI İÇİN

ŞEHİRİÇİ DAĞITIM AĞININ YENİDEN DÜZENLENMESİ

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Temmuz 2013, 89 sayfa

Elektronik ticaret (e-ticaret)'in son yıllardaki yükselişi ilgi çekmeye devam etmektedir. E-ticaret, büyük bir hızla geleneksel ticaretin yerini almaktadır. Bu değişim üçüncü parti lojistik servis sağlayıcıların (3PL) hizmetlerinde de birtakım değişiklikleri gerekli kılmıştır. E-ticaret gönderileri geleneksel gönderilerden ortalama teslimat boyutu ve teslimat yoğunluğu bakımından farklı olduğundan, üçüncü parti servis sağlayıcılar şehir içi dağıtım ağlarını yeniden düzenlemektedirler. Bu çalışma, özellikle e-ticaret teslimatları için uygulanabilecek olan bir dağıtım fikrini konu almaktadır. Çalışmanın amaçları; (i) e-ticaret teslimatları için şehir içi dağıtım ağının yeniden düzenlenmesi ve (ii) yeni dağıtım ağının olası etkilerinin analiz edilmesidir.

Anahtar Kelimeler: e-ticaret, araç rotalama, konum belirleme

To my parents

ACKNOWLEDGMENTS

I would like to express my gratitude to all those who gave me the possibility to complete this thesis. First and foremost, I would like to thank to my family for all their support since my birth. I am deeply indebted to my supervisor Özgür Özpeynirci, whose contribution and encouragement helped me in all the time of this research. I would also like to thank to Prof. Dr. Murat Aşkar for his valuable comments. My thanks are extended to the managers at UPS; Mr. Alan Amling and Mr. Jeffrey Enyart for sharing corporate information and their opinion about this research.

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INTRODUCTION

The change in productions patterns influenced the transportation trends. Today, delivery speed and reliability are the most important indicators of the success for a transportation company. For this reason, parcel service industry has been the fastest growing transportation mode in the world.

Since last years, the rise of electronic commerce (e-commerce) has captured a lot of interest. E-commerce is quickly superseding traditional commerce.

Xing et al. (2011) state that; the growth in online shopping had introduced challenges for physical distribution service quality provided by retailers and logistics service providers (LSPs).

Xu et al. (2011) believe that; with the growth of e-commerce retail service, the conflict between e-commerce logistics and traditional parcel delivery system had clearly emerged. For this reason, a revision in parcel delivery is an urgent task for the construction of e-commerce logistics system.

E-commerce deliveries differ from traditional deliveries in two main aspects: the average shipment size and the frequency of deliveries. As a result

third party logistics service provider (3PL) companies are redesigning their distribution networks in order to simultaneously decrease the costs and increase the on time delivery performance. Table 1 represents the differences between traditional delivery and e-commerce delivery.

Table 1: Characteristics of e-commerce delivery

Attributes	**Traditional Delivery**	**E-Commerce Delivery**
Distribution chain	Producer/wholesaler/retailer	E-retailer / customer
Shipment size	Large	Small
Shipment type	Homogeneous	Heterogeneous
Number of loads	High	Low
Number of delivery stops	One or more stops	Many stops
Delivery failure	Low	High
Delivery frequency	Low	High
Delivery time sensitivity	Low	High
Number of vehicle required	Low	High
Vehicle size	Large	Small
Delivery cost per each load	Small	Large

Source: Nicholls, A. and Watson, A. (2005), "Implementing e-value strategies in UK retailing", International Journal of Retail & Distribution Management, Vol. 33 No. 6, pp. 426-43.

Masmoudi et al. (2013) state that in the e-commerce field, offering good quality home delivery service is a key to satisfy customers and earn their loyalty.

Some companies are designing innovative order-fulfillment strategies to increase service quality. Leveraging existing resources for better coordination

in order placement stage and making good use of information are the most significant points for success.

According to V.Kamarainen (2003), home delivery is an operational element of logistics and the home delivery problem is equal to the vehicle routing problem with time window constraints.

This paper proposes an extension for the vehicle routing problem by formulating a mathematical model which determines some parcel consolidation points from retailers, named as alliance locations, in order to decrease the overall distribution cost for the logistics service provider.

The outline of the thesis is as follows: Chapter 2 is providing detailed information about the parcel delivery service, e-commerce, e-fulfillment concepts, industrial applications and strategic alliances.

After providing the background information, Chapter 3 is introducing the methodology used during the thesis. This chapter is including a questionnaire and brief information about vehicle routing problem (VRP). The chapter is ending with defining the problem and providing solutions for some instances. The thesis is concluded, and future work is reviewed in Chapter 4.

Chapter 2

BACKGROUND INFORMATION

This chapter is providing brief information about parcel service industry, e-commerce and strategic alliances. E-fulfillment concepts and their industrial applications are also discussed during this section.

2.1 Parcel Service Industry

Morlok et al. (2000) indicate that parcel business is formed of companies that transport shipments which are easily handled by a single person without assistance, but greater than a single letter. Parcel carriers have different services rather than other transportation service providers. Their most important features are; carrier pick-up at origin and carrier delivery to the destination. UPS, Fed-Ex, DHL and TNT are the most cognoscible brands operating in the industry.

The logic behind the parcel service operation is unique in the transportation industry, which also clarifies how parcel carriers connect to traditional modal carriers. To transport a small package for a reasonable price; parcels should be aggregated into large batches for movement, and

disaggregated prior delivery. Operation for a carrier which only uses road transportation proceeds as shown in Figure 1.

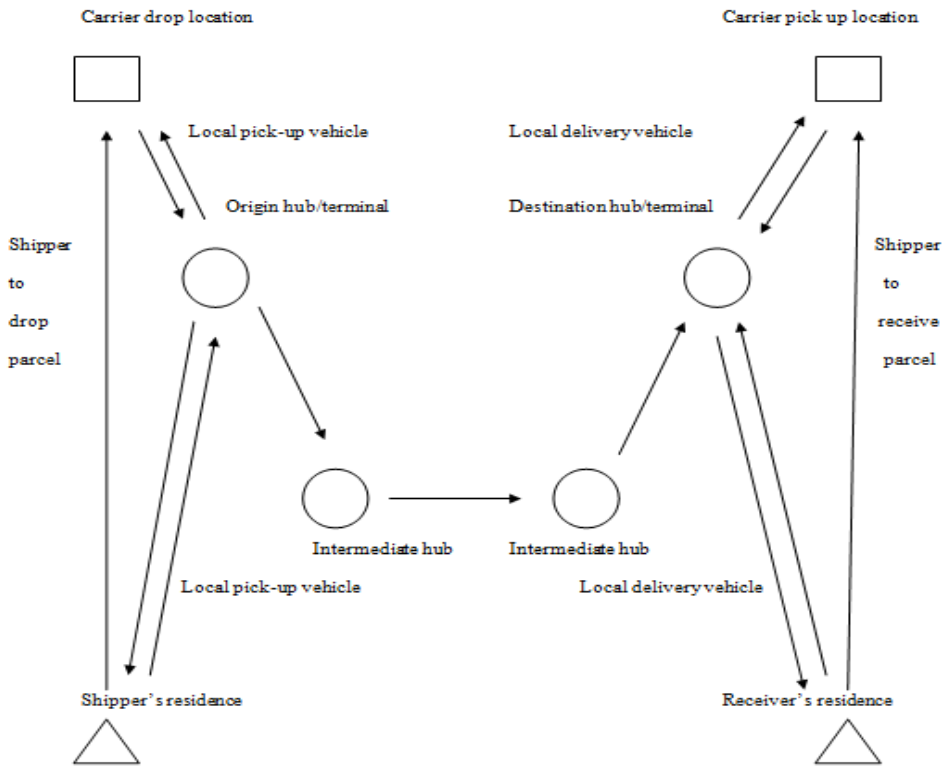

Figure 1: Steps in parcel movement

The shipments are picked up by drivers or couriers with local area vehicles, which operate inside a pre-determined territory. Once completed, these vehicles are directed to a hub or terminal which shipments are consolidated for sorting. After sorting, the parcels are loaded into outbound line haul trucks and depart to next terminal or hub on the parcel's route. The line

haul trucks are discharged at this location and parcels are sorted again. If the hub/terminal is the destination hub/terminal for the parcel, it is loaded into a local area vehicle for delivery. If it is the intermediate hub for the parcel, it is loaded into another outbound line haul truck till it reaches the destination hub.

Morlok et al. (2000) state that; pick-up/delivery services are performed via self owned assets and line haul connections are outsourced. Depending on the service preference of the customer, transportation mode could vary during line haul connection phase. In order to meet delivery time commitments for long distances, aircrafts should be used instead of trucks. Railway connection could also be used for moderate distances.

Morlok et al. (2000) see parcel carriers as integrated carriers because of integrating several types of transportation (package pick-up/delivery vehicles, large line haul trucks, etc.) and different transportation modes (air, rail, and road).

Considering that there are several outsourced services, the parcel company should integrate and coordinate the operations of other parties. This linkage should be made with great time management due to delivery commitments.

There are various service offerings of parcel service providers, depending on in-transit time and pick-up/delivery location. Some services offer delivery time guarantee, e.g., within the same day, the next day before 09:00 AM, before noon, etc. Pick-up and delivery services could also vary upon the party which performs these actions. The carrier could pick-up for deliver the parcel from/to shipper's/receiver's residence or it could be the opposite.

Cost and pricing structures are determined upon the relationship between; speed, weight and distance. There is always a positive correlation between delivery speed and price, and a negative correlation between unit cost per weight and distance. Unit cost per weight is decreasing with increasing shipment distance, while there is always a premium price for speed.

The majority of parcel carriers are offering delivery time guarantees for their premium priced services. This service is essential for the shipments which are extremely time sensitive like line stopper materials, legal agreements, etc.

Another significant service offering of parcel carriers is in-transit visibility, which is known as online tracking. By the assistance of advanced technology tools, customers are now able to track their shipments at each step on timely manner. This enables them to plan their business accordingly.

Some parcel companies are even offering other value-added activities such as; facilitation of financial services, warehousing, order fulfillment and electronic information exchange.

2.1.1 Growth of Parcel Service Industry

Parcel transportation has been the fastest growing mode of freight transportation in USA and thereby in world. The dominant carriers in USA industry are; UPS, Fed-Ex, Airborne and USPS. Eno Transportation Foundation (1998) indicates that these carriers are representing approximately 90% of the industry in total revenue. Table 2 compares the parcel revenue with national freight revenue.

Table 2: Parcel revenue compared to national freight revenue

		$ Millions	
Year	Big Four Parcel Revenue	National Freight Bill	Ratio of Package Service to Bill%
1988	17.872,00	313.040,00	5,71
1989	19.948,00	329.103,00	6,06
1990	22.046,00	350.831,00	6,28
1991	24.184,00	355.215,00	6,81
1992	26.145,00	375.093,00	6,97
1993	28.389,00	396.306,00	7,16
1994	30.909,00	419.904,00	7,36
1995	33.181,00	444.452,00	7,47
1996	35.635,00	467.510,00	7,62
1997	37.877,00	503.491,00	7,52
1998	41.322,00	527.659,00	7,83
Growth %/yr	8,74	5,36	3,21

Source: Eno Transportation Foundation, Inc. (1998). Transportation in America, p.40 (The Nation's Freight Bill). Supplement to the 16th edition, Transportation Quarterly, Vol. 53, No.3, Summer 1999, p v.

If we compare the revenue growth between modes, we could also see that air and parcel transportation modes are at the fastest growing modes.

Table 3: Revenue comparison between modes, 1960-1998

$ Millions

					Truck Expenditures	
Year	Parcel	Rail	Water	Air	Local	Intercity
1960	1.042,00	9.028,00	1722,00	220,00	14289,00	17958,00
1965	1.328,00	9.923,00	1822,00	428,00	23779,00	23628,00
1970	1.958,00	11.869,00	2070,00	720,00	28819,00	33553,00
1975	2.645,00	16.509,00	3292,00	1073,00	37287,00	47400,00
1980	6.567,00	27.858,00	7219,00	2802,00	60545,00	94551,00
1985	12.139,00	29.150,00	7703,00	5498,00	82200,00	123200,00
1990	22.046,00	30.067,00	7940,00	10100,00	108350,00	162300,00
1995	33.181,00	34.343,00	7712,00	13897,00	128352,00	219627,00
1998	37.880,00	35.350,00	7700,00	16340,00	143740,00	257810,00
Growth %/yr	9,92	3,66	4,02	12,00	6,26	7,26

Source: Eno Transportation Foundation, Inc. (1998). Transportation in America, p.40 (The Nation's Freight Bill). Supplement to the 16th edition, Transportation Quarterly, Vol. 53, No.3, Summer 1999, p v.

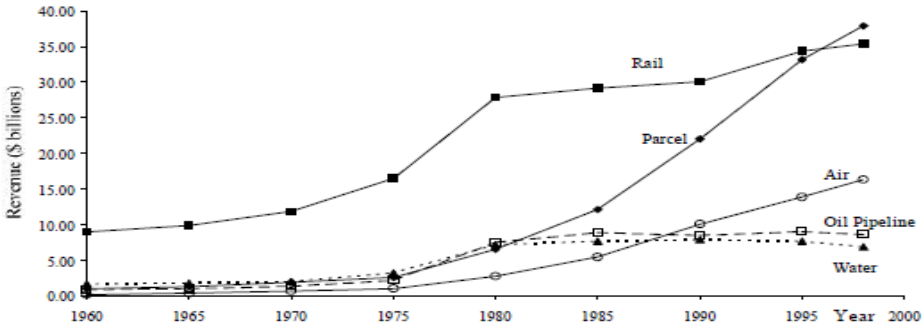

Figure 2: Revenue comparison between modes, 1960-1998

Source: Eno Transportation Foundation, Inc. (1998). Transportation in America, p.40 (The Nation's Freight Bill). Supplement to the 16th edition, Transportation Quarterly, Vol. 53, No.3, Summer 1999, p v.

The Commodity Flow Survey of 1993 and 1997 analyzed the industries which are the major users of parcel service:

- Medical Equipment
- Medical Supply
- Computer and Related Electronic Equipment
- Clothing and Accessories
- Office Supplies
- Military Ordinance and Precision Equipment
- Hardware
- High Technology Engineering and Scientific Activities in Research and Industry
- Musical, Sports and Hobby Equipment and Supplies

- General Industrial Equipment and Parts
- Printing and Publishing (periodicals, books, advertising, etc.)
- Consumer Electronic Equipment (TV, Radios, etc.)
- Industrial Machinery and Parts
- Aircraft Parts
- Electrical Transmission and Distribution Equipment
- Photographic, Equipment and Supplies

It could easily be said that parcel service is preferred for the transportation of high valued items.

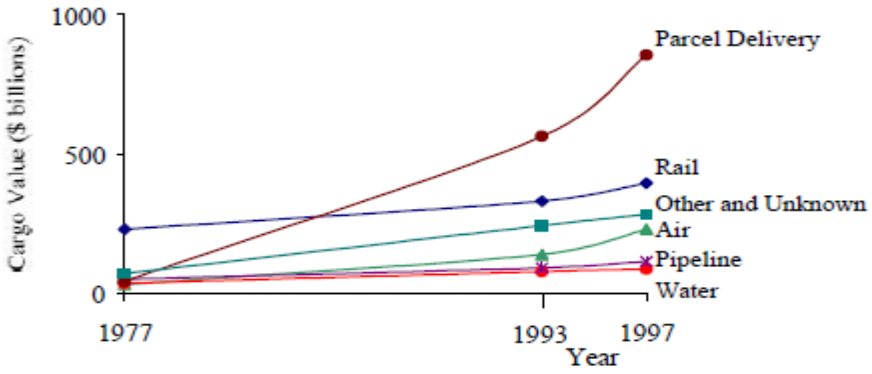

Figure 3: Comparison of parcel service and other modes in value of shipments, 1977-1997

Source: U.S. Department of Commerce, Bureau of the Census, (1999). 1997 Economic Census, Transportation-1997 Commodity Flow Survey, Table 7 Shipment Characteristics by Two-Digit Commodity and Mode of Transportation for the United States: 1997 (U.S. Government Printing Office, Washington D.C.)

2.1.2 Future of Parcel Service Industry

Parcel service industry had grown so rapidly since last decades and this growth is expected to continue. Changing production patterns is considered to be at the center behind this peak.

With the change in production patterns, there had also been change in transportation trends. In today's transportation system, an item which is sold must be delivered at the quickest way with reliability. Besides giving transportation service, parcel carriers are also providing essential services like pick-up and delivery to personal residences, tracking information which establishes an information flow.

Pais (1994) stated that ``*For the transportation industry, the talking points to remember when making step-function change include the following:*

- *A manufacturing lot size of one,*
- *Material continually moving,*
- *Value added every step, and*
- *Manufacturing's dependence on transportation to move even the smallest lot with the highest frequency and speed possible*``

These four major trends which played a significant role in this change could be conceptualized as; mass customization, inventory reduction, technology, service diversification and retailing.

Mass customization: Mass customization, could be also referred as build to order. Instead of producing large batches of items and holding them as inventory, final configuration could be postponed until customer's customized order is received. The significance of parcel carriers is high in this type of production lines. The final delivery should be handled with reasonable price, in acceptable time frames.

Inventory Reduction: Parcel service reduces inventories by; reducing the need for safety stocks with highly reliable delivery commitments and reducing the in-transit time (in-transit inventory) with faster deliveries. Figure 4 represents the inventory as percentage of GDP between 1980 and 1997.

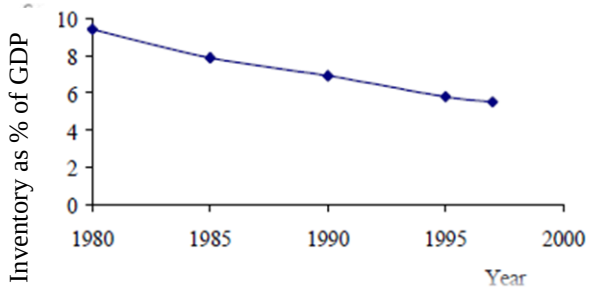

Figure 4: Inventory as percentage of GDP, 1980-1997

Source: Congressional Information Service (1998). "Manufacturers' Shipments, Inventories, and Orders: 1970 to 1997," No. 1237. In Statistical Abstract of the United States, 1998.

Technology: Technology is becoming more vital in our daily life and high tech tools are generally delivered with parcel carriers because they are high valued items which need to be handled more carefully and time sensitive in most cases.

There are also some examples which parcel carriers are participating at the repair process of these tools. Intermec Technologies had agreed with UPS for the shipment of printers which are sent back to them for repair by end users. For this purpose, they had built a warehouse to repair the returned printers next to UPS hub in Louisville. The goal is to be next to a parcel carrier's hub to reduce the inventory cycle time.

Service diversification: Parcel carriers are expanding their services to provide integrated end-to-end logistics solutions. At past; residential pick-up and delivery were seen as a value added service but nowadays enterprises are coming up with several solutions to fasten the process.

Retailing: With the effect of globalization, international trade volumes are increasing over years and barriers in front of global trade are being removed. Consequently the number of transported items and the portion of parcel carriage are increasing.

The expansion in telephone and internet sales is also affecting the vitality of parcel industry. Now, it's the era of e-commerce and retailing industry faced tremendous changes.

Before the introduction of terms like, globalization, mass customization and just-in-time customers were only able to purchase what is on the shelf on the retail market. In other words, end customers were pulling the products which are on hand as inventory and retailers were pushing what they have on hand. With the emergence and expansion of e-commerce this figure had changed dramatically. Today, the customers are ordering their items over internet or telephone to be delivered to them. Customers are pushing the retailers at first stage and retailers are pulling out orders from customers.

Morlok et al. (2000) claim that during 1980's and early 1990's retail stores were served by warehouses of wholesalers and distribution centers of manufacturers. End customer was only able to fulfill their needs from the retailers. This figure had changed during 21st century. Inbound needs of the retails stores are supplied by the distribution center or mega store which is operated by the manufacturer. The end customer could either be served by the retails store, or by the distribution center o mega store operated by the manufacturer.

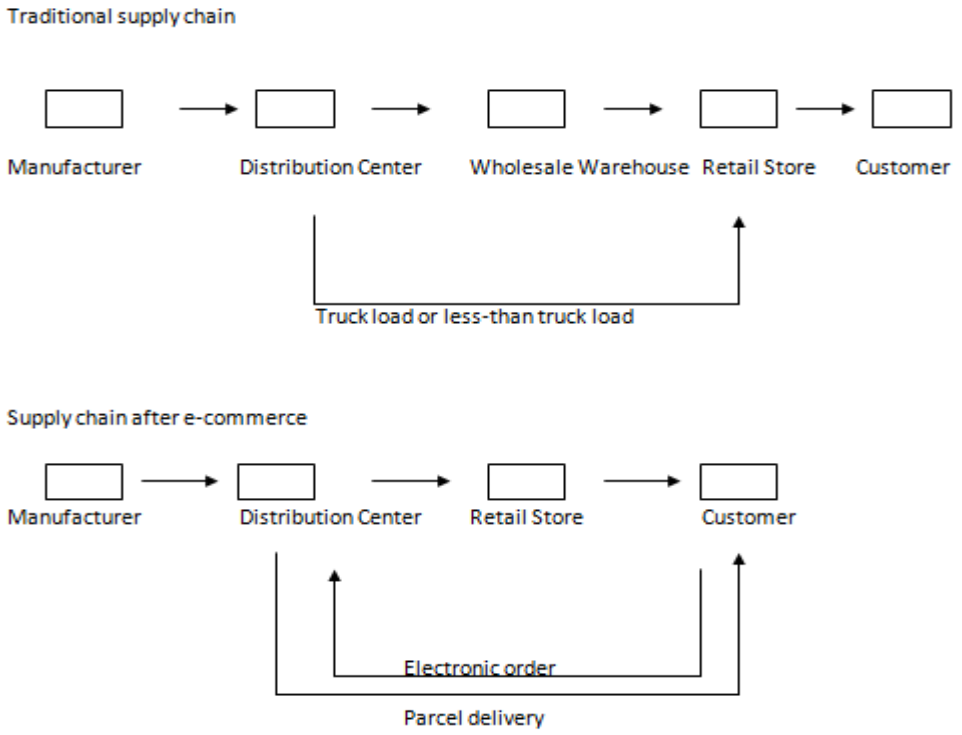

Figure 5: Changing patterns in retail chain

Source: Satish Jindel (1999) 'Delivering E-commerce' Air Cargo World, March

Kai Huang et al. (2010) state that; many electronic retailers (e-tailers) had established close partnership with widespread convenience stores in the area of retailing delivery system originating from resolving delivery problems, so that customers could order the goods on websites and pick up their ordered goods at the convenience store based on their scheduling preferences.

This delivery model provides customers with service of shopping on-line in an electronic store and picking up goods at a preferred convenience store.

Feng & Huang (2005) state that, in Thailand over 1,200,000 transactions had been completed via electronic commerce through the retail delivery mechanism per month.

Parcel service industry is the fastest growing transportation mode and it's estimated that this growth will continue. The following subsection will cover another massively growing industry: e-commerce.

2.2 E-Commerce

Electronic commerce (e-commerce) is now at the center of our life. A large number of e-commerce activities are becoming a vital part of daily life, which most of them are in the finance and retail industries. Some of these activities are; online banking, online stock-exchange, online financial instrument trading and online retailing.

According to Gunasekaran et al. (2002); internet is opening up new trading and information exchange opportunities for us and the world is just one click away to us. It's pretty clear that internet had revolutionized the world and it will bring a much more wealth to earth over time.

E-commerce is seen as one of the most important fruit which internet had introduced us, and it's expanding rapidly. Morphett (1999) represents that in 1997, the e-commerce market was estimated to be $10 billion, but it had been raised to $200-300 billion over decades.

Xing et al. (2011) indicate that during the past decade the internet has created a retail and consumer revolution by providing a new channel for shopping. In Europe, online sales were estimated to be around 2% of all retail sales in 2005 and this figure increased to 5% in 2010.

Today, most of the commercial and non-commercial organizations are participating in world-wide-web. The motivation of these tools is; information sharing between parties which conduct the supply chain and management of the relationships which emerge from these transactions.

E-commerce could be defined as conducting business between several organizations in order to reach mutual objectives. Wakid and Skall (1999) argue that it could also be referred as online marketing and trading of goods and services over world-wide-web. Consequently, every single computer or mobile device could become a massive business tool. By reducing the operational costs and transaction times, international trade is encouraged across the globe. New markets are being discovered and product availability is getting increased every single day.

Levis (1996) states that e-commerce is contributing to economic efficiency in several ways:

- Shrinking distances and timescales,
- Reducing distribution and transaction costs,
- Speeding product development,
- Providing more information to buyers and sellers,
- Widening customer choice and supplier availability.

2.2.1 Elements of E-Commerce

Kalakota and Whinston (1997) argue that e-commerce could be analyzed in four perspectives:

- Communication perspective: Information, products/services, financial instruments are delivered over electronic networks.
- Business process perspective: Automation of business processes are obtained via e-commerce.
- Service perspective: E-commerce enables to cut the service costs while increasing the service delivery performance.
- Online perspective: E-commerce enables the exchange of goods and services over internet.

As conclusion; e-commerce is trading new-era communication tools and includes all aspects of trading such as, commercial market creation, ordering, supply chain management and fund transfer. Tools used for this communication are; internet (WWW), electronic mail (e-mail), electronic fund transfer (EFT), electronic data interchange (EDI), telephone and fax.

2.2.2 Application and role of e-commerce in functional activities

E-commerce is influencing the manufacturing structure. There is a shift from mass-production to mass-customization system. Global enterprises operate several production lines at different locations; hence there are various sub-suppliers inside the supply chain. In such systems, communication and information sharing is such significant. Turban et al. (2000) believe that by using electronic bidding, main producers are able to obtain their items for 15-20% cheaper and 80% faster.

Some companies which participate at the service industry like banks and stock exchange enterprises were providing digital access to their databases even before the digital age. These companies were supplying their clients' software inside a floppy disk or CD-ROM, to give them access to their databases or

private lines. Today, this kind of software's could be obtained over internet out of charge.

As result we could say that activities which required human interaction are now automated, and become less labor-intensive. So there is a decrease in need for human representatives, while an increase on need for technical staff.

E-commerce is supporting following activities in corporations:

Marketing

- Product promotion: E-commerce provides a direct interface which contains massive information about the products.
- New sales channels: By taking the advantage of direct communication with customers, e-commerce creates alternative distribution channels for existing products.
- Direct savings: Major savings from delivery is attained by internet. It could be visible at the delivery of information and digitized products (music, films, software, etc…).
- Reduced cycle time: Administrative work and delivery time for digitized items are shortened significantly.

- Customer service: Block and Segev (1996) state that customer satisfaction could be increased by the usage of advanced technological tools like online shipment tracking and auto e-mails

E-commerce is also supporting marketing intelligence by easing; product search, widening searching criteria and product comparison.

Purchasing

Online purchasing options are forcing the business environment to change. Some intermediary roles inside the supply chain are disappearing and relationship structures are being revised.

Design

Superior designed items are have been established by using software like; computer-aided design (CAD), 3D Modeling and ProEngineer. Customer requirements are analyzed more accurately by the help of customer relationship management (CRM) software.

Production

Griffith et al. (2001) claim that; in order to compete in the rapidly changing and challenging business environment, organizations need to use fast and accurate information systems. There are various enterprise resource planning

(ERP) applications such as; MRP, SAP, BAAN, Oracle, IBM e-business and PeopleSoft. Wang et al. (2000) believe that database management, data mining and data warehousing techniques could help the enterprise to be managed more successfully.

Sales and Distribution

Internet could be used for the creation of alternative sales channels and distribution methods. Although some customers still prefer to visit retail stores (brick and mortar) for shopping, web-based retail stores (click and mortar) are growing swiftly. Information and products like music, films and software could also be distributed over internet.

Human Resources Management

Job advertisements are now made on web and the participants are evaluated upon their personal background which they upload to internet. This is a time saving preceding both for the recruiters and nominated employees.

Warehousing

Computer based technologies guide the enterprises to calculate the minimum stock level and operate with optimum level of inventory. Thus, the inventory costs are reduced and significant savings are attained.

Table 4: Application of e-commerce in organizational functions

Organizational functional areas	E-commerce applications and/or contributions	E-commerce tools and systems
Marketing	Product promotion, new sales channels, direct savings, reduced cycle time, customer services	B2B e-commerce, Internet ordering, Website for the company
Purchasing	Ordering, fund transfer, supplier selection	EDI, Internet purchasing, EFT
Design	Customer feedback, research on customer requirements, product design, quality function deployment, data mining and warehousing	WWW integrated CAD, Hyperlinks, 3D navigation, Internet for data and information exchange
Production	Production planning and control, scheduling, inventory management, quality control	B2B e-commerce, MRP, ERP, SAP, BAAN, PeopleSoft, IBM e-commerce (web integrated)
Sales and distribution	Internet sales, selection of distribution channels, transportation, scheduling, third party logistics	EFT, On-line TPS, Bar-coding system, ERP, WWW integrated inventory management, Internet delivery of products and services
Human resource management	E-recruiting, benefit selection and management, training and education using WWW	E-mails, interactive web sites, WWW based multimedia applications
Warehousing	Inventory management, forecasting, scheduling of work force	EDI, EFT, WWW integrated inventory management
Supplier development	Partnership, supplier development	WWW assisted supplier selection, communication using Internet (e-mails), research on suppliers and products with WWW and intelligent agents

Source: A.Gunasekaran, H.B. Marri, R.E. McGaughey, M.D. Nebhwani, (2002), ``E-commerce and its impact on operations management``, Int. J. Production Economics 75 (2002) 185–197

Supplier Development

Levis (1996) believes that e-commerce reduces the barriers for trade and fastens the communication process by making access to information much easier. Large number of trading partners could be compared and evaluated with advanced technology tools.

Just like parcel service industry, e-commerce is an industry which is growing rapidly. To manage the e-commerce parcel deliveries, an effective order fulfillment strategy would be required. These strategies will be analyzed in the following subsection.

2.3 Electronic Fulfillment Concepts

Order placing has been improved since years, but still it's an expensive and crucial operation for companies. The organizations which will have the edge in the future are the ones which can deliver goods and services at a reasonable cost.

If we look at a customer's point of view, an item which is purchased online cannot be utilized until it is delivered to them at the right place, at the right condition and at the right time.

Grinberg (2012) states that, e-commerce has changed the shape of traditional supply chain. Items purchased online should be transported from a plant or distribution center directly to customer's residence on time with reliability, regardless of shipment size. This implies that there is a different need for the transportation of goods from traditional delivery practices.

Some enterprises are creating innovative order-fulfillment strategies to increase their service quality. The key points are making good use of information and leveraging existing resources for better coordination in order placement stage.

Neuborne (2000) strongly believes that these companies who come up with creative ways to deliver goods and services are gaining enormous consumer loyalty.

According to Lee and Whang (2001) there are two major concepts for making e-fulfillment efficient: Using more information flow rather than physical flow and investing on existing physical infrastructures for the final leg of delivery. These two core concepts are linked to five strategies: logistics postponement, dematerialization, resource exchange, leveraged shipments and clicks-and-mortar model. Table 5 illustrates these concepts, principles and strategies.

Table 5: From concepts to strategies (Lee and Whang, 2001)

Concept	Principle	Strategy
Use information flows before, or in place of physical flows	Use information to direct final shipments (postponement).	Logistics postponement
	Convert physical flows into digital flows.	Dematerialization
Leverage existing physical channels and infrastructure	Use information to direct supply from extensive supply base.	Resource exchange
	Consolidate shipments on existing physical-flow channels.	Leveraged shipments
	Ship to an outlet with final leg covered by buyer.	Clicks-and-mortar

2.3.1 Using Information Flows Before or in Place of Physical Flows

The concept which was introduced by Lee and Whang (2001) emphasizes the better usage of information in fulfillment stage. Logistics postponement and dematerialization are the major strategies for this notion.

Logistics Postponement: Using the right information tools can help companies to run logistics more efficiently, by improving timeliness and reducing the cost of deliveries. If enterprises could wait to ship until they have more accurate information about the order, they can make more direct shipments and reduce their logistics costs. Heavy investment in information technologies is required for applying this strategy.

Hewlett-Packard is applying this strategy for their LaserJet printers which they produce. The printers are produced in Vancouver and sent to various distribution centers which are located in Europe. These distribution centers serve as assembly plants, which plugs in the power sockets for the printers before outbound from distribution centers.

Dematerialization: Material flows are generally more expensive then information flows due to the costs incurred during handling, loading and unloading, warehousing, shipping operations. Consequently, substituting

information flows for material flows makes sense, wherever it is possible. Dematerialization is an extreme form of this substitution, in which a physical product is completely replaced by information. Electronic tickets, electronic greeting cards, songs in mp3 format are some items which this strategy could be applied.

The examples and methodologies are extended in table 6.

Table 6: Innovative approaches to E-Fulfillment

Strategy	**Company Examples**	**How It's Done**
Logistics postponement	Compaq, Hewlett-Packard, Orient Overseas, Container Line	Postpone shipments using accurate information
Dematerialization	EGreetings, Intuit, MP3.com, Xilinx	Substitute digital flows for flow of goods
Resource exchange	FTD, Synchronet Marine, Tong Yang Major Corp. Cement Group	Implement virtual resource sharing at multiple sites
Leveraged shipments	Streamline, ECLine.net, Webvan	Utilize existing network for shipments
Clicks-and-mortar	7dream.com, CVS, Return.com	Have customers pick up products at physical outlets

2.3.2 Leveraging Existing Physical Channels and Infrastructures

The aim of the second concept introduced by Lee and Whang (2001) is leveraging existing resources for performing order fulfillment. Resource exchange, leveraged shipments, and clicks-and-mortar are the major strategies for this notion.

Resource Exchange: Resource exchange could be defined as pooling resources of various companies. These resources could be; Web servers, information systems, warehouses and transportation equipment.

Synchronet Marine, which operates as an e-marketplace for exchanging maritime containers, could be a good example for this strategy. Let's assume that company X needs a container from İzmir to Shanghai but they cannot find any available container. But, company Y has a container sitting idle in İzmir and cannot fill it. Both of these companies will benefit if company Y lends it container to company X.

Leveraged Shipments: In e-commerce, the order size of each customer is small. The delivery cost is justified only if there is a high volume of orders located in close proximity, or the value of order is large enough. If the orders are both small and distributed over a wide region, the cost of delivery is

excessively high. There is a simple measure called delivery-value-density (DVD), which helps to decide whether it's economical to deliver the goods to neighborhood area in one trip. DVD is computed by dividing the average total dollar volume of the shipment per trip by the average travel distance per trip.

There are several industrial applications which became successful by increasing DVD values. A Boston based online grocery store named Streamline improved its DVD by offering customers delivery on a company specified day of the week. The customers located in the same neighborhood received their deliveries on the same day. ECLine of Korea, a third party service provider, hired a network of localized home delivery service providers as dealers. ECLine handles the backbone deliveries to the dealers and dealers take care of local deliveries. The item is picked up from the retailer by the trucks of ECLine, and dropped off to the depot of the dealer. Then, the dealers deliver these packages to their final destinations in respective neighborhoods multiple times a day by a motorbike. The company increases its DVD, clients get a good service at a low price and everybody is satisfied. ECLine has filled a Korean patent for its business model. DHL applies the similar strategy with post offices in Asia.

Clicks-and-mortar model: The object of this strategy is to elicit customer cooperation for the final leg of the delivery. If an e-company's physical assets are near to customers and deliveries from supply plants in

economic, then the company could be able to get customers to handle the final delivery. If the retailer also has their own retail stores, they can use them for final delivery to customers. The retailers could also partner for other retailer channels for delivery of goods. Customers could also use the web-sites to search for product information and then go to a local shop or dealer to pick up what they need. For success, the retailers must have a high link between their suppliers and outlets.

7-Eleven, the largest and most successful convenience store chain in Japan, established a joint venture with six other Japanese giants (Mitsui & Co., Sony Corp., JTB corp., NEC corp., Nomura Research Institute and Kinotrope) using CAM model. They established a web site named 7dream.com which offers a large pool of products. Customers pick up products from stores of various 7-Elevens after 2 or 3 days when they order.

Table 7 helps to identify the suitable strategy for different products and environments.

Table 7: Using the right strategy

Strategy	Suitable Products	Suitable Environment
Logistics postponement	High-value, bulky items with uncertain demand	Information-based logistics-service provider and timely order information available.
Dematerialization	Information-content goods	Information infrastructure has sufficient capacity.
Resource exchange	Low-value, high-shipping-cost items	Distributed and substitutable stocks are available for pooling.
Leveraged shipments	Non-bulky items with stable demand	High delivery-value density (DVD) in and existing delivery network is available.
Clicks-and-mortar	Easy-to-carry items with higher value	High DVD to conveniently located physical outlets is available.

Table 8 represents the milestones and steps to be taken in order to have an effective order fulfillment strategy.

Table 8: Keys to Winning Last Mile

Milestones	**Steps**
Understanding product characteristics	Where your customers are and what are the delivery-value densities?
	What level of demand uncertainty exists for your product?
	What fraction of your products can be dematerialized?
Understanding environment	What is the existing physical infrastructure in customer regions?
	What information networks are available?
	Are there reliable information-intensive logistics-service providers?

Formulate your options?	Use as much dematerialization as possible.
	Use information to coordinate your deliveries intelligently.
	Explore potential links to existing infrastructures and partnerships for leveraged resources.
Assess your options.	Consider cost, efficiency, reliability and risks.
	Identify additional values and services that can be offered to customers.
	Explore synergies between online and offline order fulfillment.

The upcoming subsection will illustrate the real-world delivery networks designed to have an effective order fulfillment strategy within parcel service industry recently.

2.4 Industrial Applications

In this section some parcel service enterprises which had established and applied alternative service structures for e-commerce shipments are analyzed.

Three different companies are selected according to their operational service range: worldwide, regional and national. These companies are UPS, GLS Denmark and Collect +. UPS provides worldwide service and operates in more than 220 countries. GLS is a regional company operating in Europe. Collect + operates in Great Britain as a national service provider.

2.4.1 Service Requirements in Parcel Service Industry

Customer satisfaction has become one of the key operational goals for most of the enterprises because it's understood that winning a new client is much more expensive than keeping an existing one. Hence, it's easy to understand that there is positive correlation between customer loyalty, customer retention and operating profit. Bose (2002) states that; from a customer's point of view service quality is a significant element in parcel carrier selection.

Electronic commerce had revolutionized how the goods are sold and how they are delivered. Li et al. (2006) believes that the parcel service industry is an important element of the transportation sector and it gained much more significance during electronic-business era.

High speed, flexibility and convenience are the major concerns for clients in the information generation. There is no tolerance for; extended time-in-transits, backlogs or insufficient return policies. As a matter of fact, enterprises are trying to improve their customer service levels by bringing up alternative solutions.

2.4.2 United Parcel Service

United Parcel Service (known as UPS) is the world's largest parcel delivery company and leading provider of transportation and logistics services. The headquarters of the company is located in Atlanta, Georgia, USA.

The company's website announced the delivery volume for 2010 as 3.94 billion packages and documents within a service area which covers more than 220 countries. Their network consists of 1,801 operating facilities with 400,600 worldwide employees who serve 8.5 million customers daily.

Tibbs (2012) stated that UPS established its first retail distribution model at late 1990's. Texaco gas stations at Benelux (Belgium-Netherlands-Luxembourg) region were determined as customer pick-up points. The motivation for UPS was creating additional access for customers while picking-up their parcels. The target for this service was late-night engineers, who replaced damaged hardware components with new ones. Texaco gas stations were suitable for this service because; they had lots of locations, extended working hours and their agreement model was acceptable. Their motivation was creating additional access for customers while picking-up their parcels.

Tibbs (2012) believes that Texaco business ended because it was an early launch. During those days, information technologies weren't commonly used as today. Most of the time, the packages which are received by gas stations were picked-up late by the customers because they were unaware that their parcels were at the gas stations. Now, the customers are alerted by emails and SMS once their packages receive the retail stores. Moreover, the marketing efforts to introduce this service to clients were insufficient.

A parallel business model was developed in Japan and 7-Eleven convenience stores were selected as retail customer pick-up points. 7-Eleven is the world's largest convenience store which has more than 39,000 retail outlets around the world and more than 12,000 of them are operated in Japan. The

business model achieved success because the combination between long working hours of Japanese people and commonness of 7-Eleven stores boosted the demand for this service.

Tibbs (2012) states that UPS isn't the first applier of retails solutions model in the market, and with the rapid development in technology parcel companies are adding new service lanes in order to compete.

UPS is using retailers only as customer pick-up points. There is no two way movement between retail stores and UPS worldwide. Retail locations are selected according to the population density, working hours, parking space availability and access to public transportation. Only retailers with a reputable brand are selected as partners and tight contracts with them are signed. Due to the agreement, the retailers were completely responsible from the parcel after they receive it. There are some dedicated places for storage and no matter what the size and value of parcel is a fixed cost per package paid to the retailer as share.

The delivery cost for UPS is fixed worldwide. This means there isn't any price difference between receiving a parcel at a UPS Store, retailer or home. The motivation for UPS is getting closer to its customers and being more convenient. With this service customers had more flexibility which contributed

to customer satisfaction rates. The retailers were also happy because there were more customers who visited and shopped from their stores. On the other hand, UPS had decreased their home delivery failure costs while increasing their customer service level. So efficiency is measured by both cost and delivery performance of the service.

Tibbs (2012) believes that the retails solutions are commonly preferred at Europe and Asia, where people live in flats. In USA, most of the residents are self-contained which include private garage doors and private post office boxes. If no one is home to receive the parcel, customers prefer the courier to leave the parcel in front of the garage door or post office. UPS is still running the service in Japan with 7-Eleven stores and there are similar business models in Europe and USA with various retailers.

2.4.3 General Logistics Systems Denmark

General Logistics Systems B.V (known as GLS) is a parcel company who provides service across Europe. The headquarters is located at the Netherlands and their network consists of wholly owned and contracted partner companies which cover 42 European states.

The enterprise operates with 642 branches, 38 hubs, 17,100 vehicles and 13,100 employees. The announced parcel volume for year 2010/2011 is 363

million whilst serving 220,000 to customers. Declared revenue for year 2009/2011 was 1.75 billion €.

GLS Denmark; is the subsidiary of General Logistics Systems B.V. who runs the companies Denmark operations since 1982. With their 9 depots, 1 hub and fleet of 520 trucks they are the second largest parcels operator of Denmark.

The enterprise is partnering with the department store chain Dansk Supermarked A/S (The Danish Supermarket Ltd.) for their retail chain solution. The store chains owned by Danish Supermarket Ltd. are; Bilka, A-Z, Fotex, Netto, Toj&Sko and Sailing. Under the agreement; the retailers which are controlled by Danish Supermarket Ltd. are serving as pick-up and drop-off points for GLS Denmark.

Nowadays, people lack of free time and they want to get so many things done in a short period of time. It is estimated only Bilka retail stores are visited by six million customers each year. With this alliance; clients are able to send and receive their packages during shopping. The service responds to the needs of modern-day customers by providing facile store accessibility, extended operating hours and parking spaces.

Table 9: Number of store chains owned by Danish Supermarket Ltd.

Retailer	**Store Number**
Netto	411
Fotex	87
Toj&Sko	37
Bilka	17
Sailing	2
A-Z	2
Total	556

Source: http://en.wikipedia.org/wiki/Dansk_Supermarked_Gruppen

In order to provide a convenient shipping option, the shop-in-shop parcel concept was launched by GLS Denmark during 2005. The concept was totally successful and by the year 2011 GLS Denmark operates a network of 575 retail service points.

General Manager of GLS Denmark Karsten Klitmoller stated in an interview which was posted at post and parcel info that; even though the shop-in-shop parcel stores serve as pick-up and delivery points, the stores are commonly serve as customer pick-up points.

By taking the advantage of their extended network, GLS Denmark also provides functional e-commerce delivery solutions. Regarding to the large number of parcel shops, online shoppers are able to get their products delivered to a specified parcel shop rather than home.

The value-added service helps reducing the expensive home delivery failure costs for the enterprise. There are more than 400 Danish online retailers which are collaborating with GLS Denmark. By this service; the shipping volumes delivered to parcel shops had increased by 240% between April 2010 and March 2011.

2.4.4 Collect +

Collect + is a UK based parcel delivery and returns service established in 2009 as a joint venture between Yodel (formerly Home Delivery Network) and PayPoint (UK's retail payment network). Collect + operates through a network of intentionally selected PayPoint stores, while offering flexible and convenient returns and delivery service.

PayPoint is a leading international provider of convenient payment and value added services to the utility, telecoms, media, financial, transport, retail, e-commerce and public sectors, delivered through a unique combination of

local shops, the internet and mobile phones. There are more than 23,000 outlets using PayPoint terminals in UK and Ireland.

Collect + enables online shoppers to pick-up and drop-off their packages at one of 3,800 participating local stores, which gives them more freedom and flexibility.

Figures shared by Collect + in their website indicate that 39% of the customers using the service are visiting the local shops for the first time. Moreover, 38% of the Collect + customers buy products from the stores while picking-up or dropping-off their parcels. For 80% of the customers, the service is encouraging them to use the store again.

The annual store revenue had increased by £1,300 on average, after providing the delivery and returns service. The figures illustrate that the participant stores are visited by customers who had no reason to visit these stores before, and the stores are building relationships with new customers who create additional revenue for them.

As a matter of fact that there should be strategic and long term relationship between the parcel service provider and retail drop-off points, the concept of strategic alliances will be reviewed in the following subsection.

2.5 Strategic Alliances

Strategic alliances had been an important fact of business life since joint ventures were formed to take advantage of natural resources. Although there is shift in the motives for alliances; the number of alliances had increased rapidly since last decades, especially in technology intensive industries. Mowery et al. (1996) state that high level of knowledge and technology transfer is attained via joint research & development and product development stages.

Dividing the risks and costs of innovation, capital requirements and knowledge sharing are the motives for strategic alliances. Shortened product life cycles, high product development costs and risks are leading to extensive penetration to foreign markets, which could be easily established by strategic alliances. Mowery (1988) argues that some alliances still focus on collaboration between users and suppliers of new products as a means of coordinating and formulating technical standards and 'dominant designs'. Strategic behaviors also play a role in alliances which are formed to facilitate strategic coordination among competitors to increase market power.

Acquisition of new technical skills or technological capabilities from partner companies is one of the most commonly applied strategies for collaboration. Alliances have advantages rather than regular contracts or

markets for this task because firm-specific technological capabilities are generally based on tacit knowledge which is subject to considerable uncertainty concerning their characteristics and performance. Mowery (1983) believes that these attributes make it hard to draft simple contracts governing the sale or licensing of such capabilities.

Alliances can lead to gaining superior access to technological and know-how capabilities by combining incentive structures in the market while monitoring capabilities and administrative controls related with the organizational hierarchy. Alliances could also shape simple contracts like licensing, and transform them to complex agreements like technology sharing while protecting the equity of separate entities.

2.5.1 Types of Alliances

De Man (2002) believes that alliances are forms of cooperation between one or more independent companies, in which they share risks and revenues with the aim of jointly achieving a stronger competitive position.

De Man (2002) dictates that there are numerous types of alliances including; licensing, joint R&D, joint ventures, and minority participations. He strongly believes that alliances have a broader scope than market transactions, but less far-going than mergers and acquisitions. Although the number of

alliances is growing, the number of alliances involving an equality relationship is decreasing sharply.

Companies are focusing more on entering into contractual alliances instead of investing to each other or entering into a joint venture. This requires a lower level of investment and brings flexibility. It's also easier to sign or terminate a contract rather than selling an equity stake. This phenomenon is making alliances less visible because it's hard to trace which company is working with other. The competitive business environment is pressuring several industries to work within this structure.

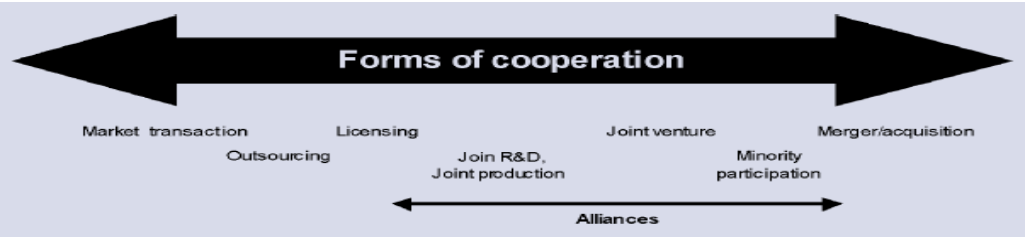

Figure 6: Forms of cooperation

Source: A.P. de Man (2002), ``How to analyze alliance networks``, Competitive Intelligence Magazine (2002)

2.5.2 Success Factors in Strategic Alliances

According to ``Supplier Alliance Research Model`` developed by Mohr and Spekman (1994), the success of alliance is depending to four factors: attributes of the alliance, communication behavior, conflict resolution techniques and commodity/supplier selection process. Below figure shows the elements which are required for a successful alliance and how the success could be measured.

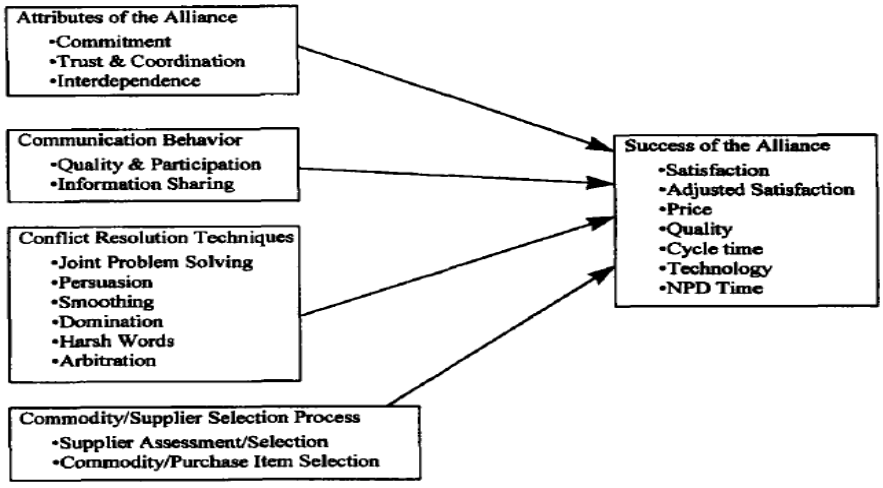

Figure 7: Supplier alliance research model

Source: Mohr, J., & Spekman, R. (1994). Characteristics of partnership success: Partnership attributes, communication behavior, and conflict resolution techniques, Strategic Management Journal, 15(2), 135-152

Chapter 3

METHODOLOGY

The chapter begins with a questionnaire which could help to anticipate public opinion for an alternative distribution model. The daily distribution of a parcel service provider could be defined as a vehicle routing problem, and an overview for vehicle routing problem is provided. After then, the research model is explained and problems are defined as mathematical models. The chapter is ended by solving the models for several instances.

3.1 Questionnaire

In order to anticipate the possible reaction of public to an alternative delivery service to retail stores, a questionnaire was practiced at Istanbul between March13 and May13 over 250 people at a parcel service provider's residence.

3.1.1 Survey for Using Alliance Locations in Parcel E-Commerce Deliveries

Gender Male ☐ Female ☐

Age 10-20 ☐ 20-30 ☐ 30-40 ☐ 40+ ☐

Do you use online retail stores or shop over internet? Yes ☐

No ☐

Where do you prefer to receive your purchased items?

Home ☐

Workplace ☐

Parcel service providers residence ☐

Do you face failures in deliveries? Yes ☐

No ☐

Would you request to receive your item in place which you desire rather than your home, workplace or parcel service providers residence? (For example; retail store, gas station, pharmacy, etc…)

Yes ☐

No ☐

Would you pay any additional cost to receive your item at any of these locations listed above?

Yes ☐

No ☐

Would you trust these locations to receive your parcel in good condition?

Yes ☐

No ☐

Would you like to take your receipt from these locations in 3 days?

Yes ☐

No ☐

Would you shop from these locations if necessary?

Yes ☐

No ☐

3.1.2 Survey Results

Indicators:

- 250 participants who are using parcel service actively
- 153 male and 97 female participants
- Age dispersion
    - 62 participants aged between 10-20
    - 142 participants aged between 20-30
    - 34 participants aged between 30-40
    - 12 participants aged over 40

- 205 participants are using online retail stores
- Received at location
    - 81 participants prefer to receive their parcel at home
    - 149 participants prefer to receive their parcel at workplace
    - 20 participants prefer to receive their parcel at parcel service providers residence
- 28 participants face failure in delivery
- 236 participants could receive their parcel at another point rather than home, workplace and parcel service providers residence
- 19 participants could pay additional cost to receive their parcel at another location
- 243 participants believe that they would receive their cargo from these locations at good shape
- 243 participants would receive their parcel from these locations in 3 days
- 236 participants would shop from these locations if necessary

There were more male participants rather than female and the majority of the participants were aged between 20 and 30.

Workplaces are most preferred received at locations with 59.6% followed by personal residences with 32.4%. Parcel service providers' residences are not widely preferred as received at locations.

The majority of the participants didn't face with delivery failures. 94.4% of the participants are open to receive parcel at another point rather than these listed locations and out of these 250 people, 19 of them are willing to pay for additional charge for such service.

More than 90% of the participants who tend to use these locations believe that they would receive their parcel in good condition within 3 days and they could also shop from these locations if necessary.

Table 10 represents that gender doesn't have an impact on delivery point preference.

Table 10: Delivery point preferences by gender (%)

Delivery point preferences by gender (%)			
	Female	Male	**Average**
workplace	61	59	60
home	31	33	32
parcel service providers residence	8	8	8

Table 11 shows that people who are aged between 20-40 prefer to receive their parcels at workplace, where people which are aged over 40 prefer

to receive their parcels at home and people who are aged under 20 prefer to receive their parcels at parcel service providers' residence.

Table 11: Delivery point preferences by age (%)

Delivery point preferences by age (%)					
	10-20	**20-30**	**30-40**	**over 40**	**Average**
workplace	3	83	68	50	60
home	81	13	24	42	32
parcel service providers residence	16	4	9	8	8

Table 12 illustrates that the majority of the people who won't prefer to receive their orders from drop of points are aged over 40, but Table 13 states that 17% of them are willing to pay extra cost for this additional service.

Table 12: Preference to receive orders from drop-off points (%)

Prefer to receive order from drop-off points (%)							
		Gender		Age			
	Overall	Female	Male	**10-20**	**20-30**	**30-40**	**over 40**
No	6	5	6	6	4	6	25
Yes	94	95	94	94	96	94	75

Table 13: Willingness to pay additional fee (%)

Willingness to pay additional fee (%)							
		Gender		Age			
	Overall	Female	Male	**10-20**	**20-30**	**30-40**	**over 40**
No	92	92	93	95	94	85	83
Yes	8	8	7	5	6	15	17

There was no difference between the number of females and males which would pay an extra cost for the additional service, but the number of females which dictate that they won't shop from the drop-off points are greater than the number of males. Table 14 represents this diversification.

Table 14: Preference to shop from drop-off points (%)

Prefer to shop from drop-off points (%)							
		Gender		Age			
	Overall	Female	Male	**10-20**	**20-30**	**30-40**	**over 40**
No	6	9	3	2	7	6	8
Yes	94	91	97	98	93	94	92

It won't be wrong to conclude that people are keen to receive their parcels and shop from the retail drop-off points, but they don't want to pay any additional fee to receive their parcels from these locations.

Table 15: Willingness to pay additional fee and prefer to shop from drop-off points (%)

Willingness to pay additional fee and prefer to shop from drop-off points (%)				
	Prefer to shop from drop-off points			
		No	Yes	Sum
Willingness to pay additional fee	No	5,6	86,8	92,4
	Yes	0	7,6	7,6
	Sum	5,6	94,4	100

3.2 Vehicle Routing Problem (VRP)

For the effective management of the flow of goods and services within the distribution systems, there had been and increased utilization of optimization concept based on operations research and mathematical programming techniques. Using computerized procedures for the real-world applications in distribution planning process had lead to significant savings in transportation costs (from 5% to 20%). Thus, it's easy to comment that these savings are crucial for the global economic system. Moreover, the transportation process consists of all stages; including production, distribution and re-cycle, which represents between 10%-20% of the final cost of the goods.

The massive development in computer systems and increasing integration of information systems are the main drivers of the success for operations research techniques. Toth and Vigo (2002) state that different factor of success, as important as the others, is the development of modeling and algorithmic tools implemented in recent years. Indeed, the proposed models take into account all the characteristics of the distribution problems arising in real-world applications, and the corresponding algorithms and computer implementations find good solutions for real-world instances within acceptable computing times.

Vehicle Routing Problems (VRPs) are also known as Vehicle Scheduling Problems which concern the distribution of goods between depots and customers. The methods which are used for VRPs could also be applied in several real-world applications such as; waste collection, street cleaning, bus routing, and transportation of handicapped people and routing of salespersons.

The distribution of goods concerns the service, in a given time period, of a set of customers by a set of vehicles, which are located in one or more depots, are operated by a set of crews (drivers), and perform their movements by using an appropriate road network. In particular, the solution of a VRP calls for the determination of a set of routes, each performed by a single vehicle that starts and ends at its own depot, such that all the requirements of the customers are fulfilled, all the operational constraints are satisfied, and the global transportation cost is minimized.

The road networks which are used for transportation of goods are defined as arcs. Arcs are representing the roads between depots and customer locations. Arcs could be directed and undirected, depending on weather they could be traversed in one direction or in both directions. Every arc has a cost which is reflecting its length and time, possibly correlated with the vehicle type or the period during which the arc is traversed.

Toth and Vigo (2002) list the typical characteristics of customers are:

- Vertex of the road graph in which the customer is located
- Amount of goods (demand), possibly of different types, which must be delivered or collected at the customer
- Periods of the day (time windows) during which the customer can be served (for instance, because of specific periods during which the customer is open or the location can be reached, due to traffic limitations)
- Times required to deliver or collect the goods at the customer location (unloading or loading times, respectively), possibly dependent on the vehicle type
- Subset of the available vehicles that can be used to serve the customer (for instance, because of possible access limitations or loading and unloading requirements).

In some cases, demand of every customer cannot be satisfied. For such examples, the delivery or collection amounts could be reduces or some customers could be left as unserved. To overcome these events, different penalties or priorities could be assigned to customers.

Each route which is serving customers start and end at one or more depots, and each depot is characterized by the number and type of vehicles

related to it plus the amount of goods it could handle. Transportation of the goods are organized by a fleet of vehicles which their size and capacity could be fixed or defined according to the requirements of the clients.

Toth and Vigo (2002) define the typical characteristics of the vehicles as:

- Home depot of the vehicle, and the possibility to end service at a depot other than the home one
- Capacity of the vehicle, expressed as the maximum weight, or volume, or number of pallets, the vehicle can load
- Possible subdivision of the vehicle into multiple compartments, each characterized by its capacity and by the types of goods that can be carried
- Devices available for the loading and unloading operations
- Subset of arcs of the road graph which can be traversed by the vehicle

- Costs associated with utilization of the vehicle (per distance unit, per time unit, per route, etc.).
- Company regulations and union contracts such as; working hours per day, number and time of breaks during working hours, maximum duration of driving time, and overtime should be satisfied by the drivers which are using the vehicles.

There are several operational constraints which depend on the quality of service level, characteristics of customers, vehicle characteristics and nature of transported goods. For example; the load of the vehicle cannot exceed the vehicle capacity, the customers served in a route could require delivery and collection, or customers could be served only within a time window.

Laporte (2009) is forming a classical VRP formulation is as following: Let $G = (V, A)$ be a directed graph where $V = (0,\ldots, n)$ is the vertex set and $A = \{(i, j): i, j \in V, i \neq j\}$ is the arc set. Vertex "0" represents the depot whereas the remaining vertices represent the customers. A fleet of m identical vehicles of capacity Q is based at the depot. The fleet size is given a priori or is a decision variable. Each customer i has a nonnegative demand q_i. A cost matrix c_{ij} is defined on A. For simplicity, we consider travel costs, distances and travel times to be equivalent. The VRP consists of designing m vehicle routes such that each route starts and ends at the depot, each customer is visited exactly once by a single vehicle, the total demand of a route does not exceed Q, and the total length of a route does not exceed a preset limit L.

A vehicle routing problem could have several objectives like:

- Minimizing the total transportation cost
- Minimizing the total travelling time
- Minimizing the number of vehicles used to serve

3.3 Research Model

The goal of this study is; revising the current distribution methodology for e-commerce shipments, while decreasing the overall cost model for the service provider with increasing on-time delivery performance.

The daily delivery service of a parcel company could be defined as a standard vehicle routing problem, where there are parcels to be delivered to several delivery points. The solution of this problem is reflecting the delivery route and the total cost for a single day.

In order to meet the service requirements for today's competitive business environment, the delivery network which is going to be established for e-commerce deliveries should be different than traditional deliveries. For finding the balance between the cost and service performance and satisfying all parties, some parcel consolidation points would be determined out of retail stores as drop-off points, which would enable the clients to receive their parcels during the extended operating hours of the retail store and the parcel service provider to visit less number of delivery locations with the same batch of parcels.

This thesis tries to answer the following two questions:

1. How does a parcel service provider select the drop-off points in order to reduce vehicle routing costs?
2. How does the customer react to this system?

In order to answer the first question, we propose mathematical models that decide the number and locations of drop-off points as well as the vehicle routes. We design and apply a survey to understand potential customer reactions to the proposed system.

One can classify the decisions to be made by the parcel service provider under two folds. The first one is the selection of the retail stores to be used as drop-off points. The second one is determining the vehicle routes for a given set of parcels. The former decision is a tactical/strategic level decision whereas the latter is operational.

In this study, we propose two mathematical models for the above mentioned problems of a parcel service provider. The first model is the VRP with alliance retailers (VRP-AR). VRP-AR extends the classical VRP model with the introduction of alliance retailers as the candidate drop-off points. The inputs of VRP-AR are the locations of the parcels to be delivered and the locations of the candidate drop-off points.

VRP-AR decides:

- the drop-off points that will be used,
- the subset of the parcels that will be delivered to the customer locations,
- the subset of parcels that will be delivered to drop-off points, and
- the vehicle routes.

VRP-AR aims to minimize a weighted objective function of distances travelled by the vehicles of the parcel service provider and the customers whose parcels are dropped to one of the drop-off points.

Once the parcel service provider selects the drop-off points, these points will be used for a long time. In practice it may not be possible to use each and every drop-off point. Hence, the parcel service provider should select the drop-off points considering the demand for multiple periods instead of a single day. Note that, there is no necessity to visit every selected drop-off point every day.

The second model is multi period VRP with alliance retailers (MP-VRP-AR). MP-VRP-AR also considers the alliance retailers as candidate drop-off points. The inputs of MP-VRP-AR are the locations of the parcels to be delivered for each period and the locations of the candidate drop-off points.

MP-VRP-AR decides:

- the drop-off points that will be used during the planning horizon,
- the subset of the parcels that will be delivered to the customer locations in each period,
- the subset of parcels that will be delivered to drop-off points in each period, and
- the vehicle routes for each day.

MP-VRP-AR aims to minimize a weighted objective function of distances travelled by the vehicles of the parcel service provider and the customers whose parcels are dropped to one of the drop-off points during the planning horizon.

Moreover; in order to figure out the opinion of the current parcel service clients and estimate that if such a delivery method is suitable, a questionnaire is applied.

3.4 Problem Definition and Solutions Techniques

In this section we express the mathematical model for vehicle routing problem and extend the problem by inserting drop-off points inside the model and solving the problem for multiple days.

3.4.1 Vehicle Routing Problem

The standard vehicle routing problem is modeled as below.

Sets

$Customers;\ N = \{1,2,3,\dots,n\}$

$\{0\}; Hub$

$N_0 = N \cup \{0\}$

$Vehicles;\ K = \{1,2,3,\dots,k\}$

$A;\ Arc\ set$

Parameters

$c_{ij}\ ;\ Cost\ of\ using\ arc\ (i,j), \qquad (i,j) \in A$

$Q\ ;\ Capacity\ of\ vehicles$

$d_i\ ;\ Demand\ of\ customer$ i, $\qquad i \in$ S

$u_i\ ;\ Capacity\ of\ a\ vehicle\ after\ visiting\ customer\ i, \qquad i \in S$

Decision Variables

$$x_{ij} = \begin{cases} 1 & if\ arc\ (i,j)\ is\ used \\ 0 & otherwise \end{cases}$$

Model

Objective function;

$$\text{Min } Z = \sum_{i,j \in A} c_{ij} x_{ij}$$

The objective is minimizing the total transportation cost.

Subject to;

$$\sum_{j \in N_0} x_{ij} = 1 \quad , \quad i \in N$$

There must be an inflow arc for each node. In other words, every customer shall be visited by a line-haul truck.

$$\sum_{j \in N_0} x_{ji} = 1 \quad , \quad i \in N$$

There must be and outflow arc for each node. In other words; after a visit, the line-haul truck must depart to next customer or hub.

The next three set of constraints are used in order to eliminate the subtours.

$$u_i - u_j + Q\,x_{ij} \leq Q - d_j \;,\; (i,j) \in A$$

If the arc (*i*,*j*) is used; then the difference of the load of the vehicle after visiting customer j (except depot) and demand of j should be greater than or equal to the load of the vehicle after visiting customer *i* (except depot).

$$u_i \geq d_i \;,\quad i \in S$$

The load of the vehicle after visiting customer *i* (except depot) should be greater than the demand of customer *i*.

$$u_i \leq Q \;,\; i \in S$$

The load of the vehicle after visiting customer *i* (except depot) should be less than the capacity of vehicle.

3.4.2 Vehicle Routing Problem with Alliance Retailers

The retail locations which will serve to the potential clients are defined as alliance locations. The model which is including these drop-off points is represented as following.

Sets

$Customers;\ N = \{1,2,3,\dots,n\}$

$\{0\}; Hub$

$N_0 = N \cup \{0\}$

$Potential\ Alliance\ Retailers;\ M = \{1,2,3,\dots,m\}$

$S = N \cup M$

$S_0 = N \cup M \cup \{0\}$

$Vehicles;\ K = \{1,2,3,\dots,k\}$

$A;\ Arc\ set$

Parameters

$c_{ij}\ ;\ Cost\ of\ using\ arc\ (i,j),\qquad \forall (i,j) \in A$

$Q\ ;\ Capacity\ of\ vehicles$

$d_i\ ;\ Demand\ of\ customer\ i,\qquad \forall i \in S$

$dreal_j\ ;\ Real\ demand\ of\ customer\ j,\qquad \forall j \in S$

$u_i\ ;\ Capacity\ of\ a\ vehicle\ after\ visiting\ customer\ i,\qquad \forall i \in S$

Decision Variables

$$x_{ij} = \begin{cases} 1 & if\ arc\ (i,j)\ is\ used \\ 0 & otherwise \end{cases}$$

$$z_k = \begin{cases} 1 & if\ retailer\ k\ is\ opened \\ 0 & otherwise \end{cases}$$

$$y_{ik} = \begin{cases} 1 & if\ customer\ i\ is\ assigned\ to\ retailer\ k \\ 0 & otherwise \end{cases}$$

Model

Objective function;

$$\text{Min } Z = \sum_{i,j \in A} c_{ij} x_{ij} + \sum_{i,k \in A} c_{ik} y_{ik}$$

The objective is minimizing the total distance travelled by the vehicles and the customers.

Subject to;

$$\sum_{k \in M} z_k \leq p$$

The total number of operating alliance retailers cannot exceed p.

$$\sum_{j \in S_0} x_{ij} + \sum_{k \in M} y_{ik} = 1 \ , \quad i \in N$$

Each node must be served by a line haul truck or an alliance retailer.

$$\sum_{j \in S_0} x_{ji} + \sum_{k \in M} y_{ik} = 1 \ , \quad i \in N$$

There must be and outflow arc for each node, except the nodes which are served by an alliance retailer.

$$\sum_{j \in S_0} x_{jk} = z_k$$

If an alliance retailer is visited by a line haul truck, the retailer is operating.

$$\sum_{j \in S_0} x_{kj} = z_k$$

The constraint states that if an alliance retailer serves a customer, the retailer is operating.

$$y_{ik} \leq z_k \quad , \quad \forall \text{i} \in \text{N}$$

The constraint is added to eliminate the possibility of serving a customer by an alliance retailer, while the alliance retailer isn't operating.

$$d_k = \sum_{i \in N} d_i \, y_{ik}$$

The demand of an alliance retailer is equal to sum of the demand for each customer which is assigned to that retailer.

$$u_i - u_j + Q \, x_{ij} \leq Q - d_j \ , \ \forall (i,j) \in A$$

If the arc is used then the difference of the load of the vehicle after visiting customer j (except depot) and demand of j should be greater than or equal to the load of the vehicle after visiting customer i (except depot).

$$u_i \geq d_i \quad , \quad \forall \text{i} \in \text{S}$$

The load of the vehicle after visiting customer i (except depot) should be greater than the demand of customer i.

$$u_i \leq Q \ , \ \forall \text{i} \in \text{S}$$

The load of the vehicle after visiting customer i (except depot) should be less than the capacity of vehicle.

3.4.3 Multiperiod Vehicle Routing Problem with Alliance Retailers

In order to extend the one day solution to a multiple days, the model is extended as below.

Sets

$Customers;\ N = \{1,2,3,\dots,n\}$

$\{0\}; Hub$

$N_0 = N \cup \{0\}$

$Potential\ Alliance\ Retailers;\ M = \{1,2,3,\dots,m\}$

$S = N \cup M$

$S_0 = N \cup M \cup \{0\}$

$Vehicles;\ K = \{1,2,3,\dots,k\}$

$A;\ Arc\ set$

$Days;\ T = \{1,2,3,\dots,t\}$

Parameters

$c_{ij}\ ;\ Cost\ of\ using\ arc\ (i,j),$ $\forall (i,j) \in A$

$Q\ ;\ Capacity\ of\ vehicles$

$d_i\ ;\ Demand\ of\ customer\ i,$ $\forall i \in S$

$dreal_j\ ;\ Real\ demand\ of\ customer\ j,$ $\forall j \in S$

$u_i\ ;\ Capacity\ of\ a\ vehicle\ after\ visiting\ customer\ i,$ $\forall i \in S$

Decision Variables

$$x_{ijt} = \begin{cases} 1 & if\ arc\ (i,j) is\ used\ in\ day\ t \\ 0 & otherwise \end{cases}$$

$$z_k = \begin{cases} 1 & if\ retailer\ k\ is\ opened \\ 0 & otherwise \end{cases}$$

$$y_{ikt} = \begin{cases} 1 & if\ customer\ i\ is\ assigned\ to\ retailer\ k\ in\ day\ t \\ 0 & otherwise \end{cases}$$

Model

Objective function;

$$\text{Min } Z = \sum_{t} \left[\sum_{(i,j) \in A} c_{ij} x_{ijt} + \sum_{i,k \in A} c_{ik} y_{ikt} \right]$$

The objective is minimizing the total transportation cost within the pre-determined area for t days.

Subject to;

$$\sum_{k \in M} z_k \leq p$$

The sum of operating alliance retailers cannot exceed p.

$$[\sum_{j \in S_0} x_{ijt}] + [\sum_{k \in M} y_{ikt}] = 1 \ , \quad \forall i \in N, \qquad \forall t$$

Each node must be served by a line haul truck or an alliance retailer for t days.

$$[\sum_{j \in S_0} x_{jit}] + [\sum_{k \in M} y_{ikt}] = 1 \ , \quad \forall_i \in N, \qquad \forall t$$

That there must be and outflow arc for each node, except the nodes which are served by an alliance retailer in each day.

$$\sum_{j \in S_0} x_{jkt} = z_k, \qquad \forall t$$

If an alliance retailer is visited by a line haul truck, the retailer is operating for t days.

$$\sum_{j \in S_0} x_{kjt} = z_k \ , \qquad \forall t$$

If an alliance retailer serves a customer, the retailer is operating for t days.

$$y_{ikt} \leq z_k \ , \quad \forall i \in N, \qquad \forall t$$

The constraint is added to eliminate the possibility of serving a customer by an alliance retailer, while the alliance retailer isn't operating for t days.

$$d_k = \sum_{i \in N} d_i \, y_{ikt}$$

The demand of an alliance retailer is equal to sum of the demand for each customer which is assigned to that retailer for t days.

$$u_i - u_j + Q\, x_{ijt} \leq Q - d_j \ , \ \forall (i,j) \in A, \qquad \forall t$$

If the arc is used then the difference of the load of the vehicle after visiting customer j (except depot) and demand of j should be greater than or equal to the load of the vehicle after visiting customer i (except depot)for t days.

$$u_i \geq d_i \ , \quad \forall i \in S$$

The load of the vehicle after visiting customer i (except depot) should be greater than the demand of customer i.

$$u_i \leq Q \ , \ \forall i \in S$$

The load of the vehicle after visiting customer i (except depot) should be less than the capacity of vehicle.

3.5 Solutions

3.5.1 Vehicle Routing Problem

Considering the fact that Vehicle Routing Problem is the basis of the alternative distribution model, it was the first problem to be modeled and solved by using GAMS.

The problem was solved for multiple scenarios; by revising the number of drop-off points, number of customers and vehicle capacity in order to analyze the differences between each case. The coordinates for all parties and demand is random.

Due to fact that the used software is only able to solve the problem with a limited number of drop-off points, only a limited number of scenarios and their solutions are represented in the table below.

Table 16: Solutions for Vehicle Routing Problem

	Instances				
	1	2	3	4	5
#of locations	10	15	20	15	20
# of customers	10	15	20	15	20
Vehicle capacity	20	20	20	50	50
Opt. solution	4949	6607	9704	6511	9704
Solution time	0:00:00.278	0:00:01.809	0:00:22.834	0:00:02.987	0:01:12.069

Observations:

- There is a positive relationship between the number of locations and computing time.
- The optimal solution is increasing, within any increase in the number of locations.

3.5.2 Vehicle Routing Problem with Alliance Retailers

Similar to the Vehicle Routing Problem, the problem was solved for multiple scenarios; by revising the number of drop-off points, number of customers, # of Alliance Points and vehicle capacity in order to analyze the differences between each case. . The coordinates for all parties and demand is random.

And again due to fact that the used software is only able to solve the problem with a limited number of drop-off points, only a limited number of scenarios and their solutions are represented in the table below.

Table 17: Solutions for Vehicle Routing Problem with Alliance Retailers

	Instances				
	1	2	3	4	5
#of locations	10	15	20	15	20
# of customers	7	10	15	10	15
# of AP's	3	5	5	5	5
Vehicle capacity	20	20	20	50	50
Opt. solution	4314	3281	8787	3281	9289
Solution time	0:00:3.570	0:02:11.841	0:07:35.516 cont.	0:03:54.819 cont.	0:09:09.215 cont.

Observations:

- There is a positive relationship between the number of locations and computing time.
- The optimal solution is increasing, within any increase in the number of locations.
- The vehicle capacity doesn't have any impact over the problem which is solved with 10 customers and 5 alliance points.
- Compared with VRP, depending on the ratio of the AP's and vehicle capacity there is a significant decrease in the optimum solution for each scenario. (13%, 51%, 10%, 50% and 5% respectively)

3.5.3 Multiperiod Vehicle Routing Problem with Alliance Retailers

Time constraint is added to the Vehicle Routing Problem with Alliance Retailers model, and the solutions are representing the outcomes of a 2 day period. . The coordinates for all parties and demand is random.

Table 18: Solutions for Multiperiod Vehicle Routing Problem with Alliance Retailers

	Instances				
	1	2	3	4	5
#of locations	10	15	20	15	20
# of customers	7	10	15	10	15
# of AP's	3	5	5	5	5
Vehicle capacity	20	20	20	50	50
Opt. solution	1057	1357	1983	3157	2076
Solution time	0:03:19.921	0:05:20.618	0:07:15.789	0:05:10.855	0:03:25.614

Observations:

- There is a positive relationship between the number of locations and computing time.
- The optimal solution is increasing, within any increase in the number of locations.
- The vehicle capacity doesn't have any impact over the problem which is solved with 10 customers and 5 alliance points.
- Compared with VRP AP, depending on the ratio of the AP's and vehicle capacity there is a significant decrease in the optimum solution for each scenario. (76%, 59%, 78%, 4% and 78% respectively)

Chapter 4

CONCLUSIONS AND FURTHER RESEARCH

The growth of internet based businesses, also known as dot com's, has a great influence over today's trading patterns. There is no other industrial sector which had grown this tremendously for such a short time period.

The enterprises which are participating over the internet had developed their own models in order to become a successful business. Depending to the nature of the business, the internet age is allowing the organizations to position itself at an appropriate level of supply chain.

With the effect of globalization, just-in-time operations and lean production, the companies in the transportation sector have a key status as service providers. Parcel service providers are the heart of this increasingly time-sensitive and highly competitive sector, by shortening lead times while offering premium services.

The use of technological innovations and following up the market trends are the key points to provide an opportunity of parcel service companies. New enterprises are emerging and services are being developed in this niche transportation market every day, which is creating a great challenge in the logistics sector.

Order fulfillment is the most significant operation for businesses operating in the e-commerce market. The success of the enterprise is depending on on-time deliveries. For this reason, the delivery network for e-commerce deliveries should differ from traditional deliveries. Some companies are coming up with innovative methods for their order-fulfillment processes.

The proposed solution is determining some consolidation points out of retails stores which will serve as drop-off points for parcel service providers. This would enable the clients to receive their parcels during the extended operating hours of the retailer and the parcel service provider to serve less delivery locations with the same batch of parcel.

Considering the fact that the distribution model is also increasing the service level for end user by providing flexibility, it makes sense to apply such distribution strategy for parcel e-commerce deliveries which are highly time sensitive.

The questionnaire results indicate that gender doesn't have any influence over delivery point preference of the survey group. The majority of the people who are under the age of 40 in the survey group prefer to receive their parcels from their workplaces. As a matter of fact, the survey group is keen to use the drop-off points to receive their parcel. The survey group is also

ready to shop from these retail drop-off points, but don't want to pay an additional fee to receive their shipments from these locations.

The problem is modeled as a mathematical model and solved by GAMS software for various instances. The results represent that, depending on the ratio of the alliance retailers in the model and vehicle capacity, such delivery network is reducing the total delivery cost for the service provider from 4% to 51%.

Due to nature of the software used, the model could only be tested over a limited number of total locations. In order to test the real life applicability, the problem should be solved by heuristic techniques. This will enable to increase the number of total locations and the length of the planning horizon.

For real a real-world application, deeper analysis should be made for the determination of retail locations. Considering the fact that this is a strategic decision, the partnership details such as alliance type, responsibility areas for each partner, contract terms, duration, etc. should be clearly defined.

From the 3PL's point of view; it's much difficult to handle the operations of business to customer (B2C) trade rather than business to business (B2B) trade, because there is more batch of parcels to pick up or deliver within a wider service zone. Considering the fact that the e-commerce business is

growing rapidly, 3PL's should come up with creative service solutions to continue their operations successfully.

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